RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA

VOLUME LXVI.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1932 [June.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1931. BY L. L. FERMOR, O.B.E., D.Sc., A.R.S.M., F.G.S., F.A.S.B., M.I.M.M., *Offg. Director, Geological Survey of India.*

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DISPOSITION LIST

During the period under report the officers of the Department were employed as follows:—

Superintendents.

DR. L. L. FERMOR . . Remained at headquarters and officiated as Director throughout the year.

DR. G. DE P. COTTER . Placed in charge of the Punjab and North-West Party; left for the field on the 11th January and returned from the field on the 20th July, 1931. Remained at headquarters.

DR. J. COGGIN BROWN . Continued in charge of the Burma Party. Granted leave out of India on average pay for 1 month and 16 days combined with leave on half average pay for 5 months and 14 days from the 19th March 1931. Returned from leave and resumed duty on the 17th October, 1931. Placed in charge of the Burma Circle.

MR. H. C. JONES . Returned from leave and resumed duty on the 1st November, 1931. Remained at headquarters.

DR. A. M. HERON . . Returned from the field on the 13th April, 1931. Remained at headquarters and placed in charge of the Northern Circle.

DR. C. S. FOX . . Placed in charge of the Bihar and Orissa Party. Deputed to examine the coalfields of Assam from the 8th January to 2nd February, 1931. Granted leave out of India on average pay for 8 months. Returned from leave and resumed duty on the 4th November, 1931. Placed in charge of the Southern Circle and left for the Central Provinces on the 1st December, 1931.

Assistant Superintendents.

MR. H. CROOKSHANK . Granted leave out of India on average pay for 6 months combined with study leave for 12 months; availed himself of the same with effect from the 23rd March, 1931, from the field.

MR. G. V. HOBSON	Remained at headquarters in charge of office as Assistant Director till the 3rd November 1931. Acted as Palæontologist from the 26th March to 30th September, 1931. Granted leave on average pay for 8 months combined with leave on half average pay for 3 months from the 5th November, 1931.
MR. E. L. G. CLEGG .	Returned from leave and resumed duty on the 21st September 1931. Placed in charge of office as Assistant Director from the 4th November, 1931.
RAO BAHADUR M. VINAYAK RAO.	Remained at headquarters till the 13th February, 1931. Granted leave on average pay for 6 months and 2 days combined with leave on half average pay for 17 months and 29 days from the 14th February, 1931, with permission to retire on the expiry of leave.
MR. E. J. BRADSHAW .	On leave.
MR. A. L. COULSON	Returned from the field on the 18th April, 1931. Placed in charge of the Burma Party during the absence of Dr. J. Coggin Brown on leave and left for Rangoon on the 26th April, 1931. Returned to Calcutta on the 22nd October, 1931. Attached to the Southern Circle to carry on the survey of the asbestos field in the Cuddapah district, Madras. Left for the field on the 9th December, 1931.

MR. D. N. WADIA	Continued to act as Palæontologist till the 25th March, 1931. Attached to the Punjab and North-West Party. Left for the field on the 25th March, 1931, and returned on the 11th September, 1931. Remained at headquarters as Palæontologist from the 1st October, 1931.
DR. J. A. DUNN	Continued to act as Curator of the Geological Museum and Laboratory till the 19th April, 1931. Granted leave on average pay for 4 months combined with leave on half average pay for 10 months and 24 days from the 10th July, 1931.
MR. C. T. BARBER	Continued as Resident Geologist at Yenangyaung and Official Member of the Yenangyaung Advisory Board. Granted leave on average pay for 1 month from the 25th September, 1931, with permission to affix Sunday, the 25th October, and the Burma gazetted holidays from the 26th October to the 2nd November, 1931. Returned from leave and resumed duty on the 3rd November, 1931.
MR. E. R. GEE . .	Granted leave out of India on average pay for 4 months and 10 days combined with study leave for 2½ months; availed himself of the same with effect from the 20th March, 1931, from the field; returned from leave and resumed duty on the 25th October, 1931. Attached to the Northern Circle and left for the Salt Range Punjab, on the 4th December, 1931.

Mr. W. D. West		Returned from the field on the 4th July, 1931. Deputed to Quetta from the 28th August to 15th September 1931, to examine the effects of the earthquakes. Appointed as Curator of the Geological Museum and Laboratory from the 1st November, 1931.
Mr. A. K. Banerji	.	Returned to Rangoon from field work in Mogok Stone Tract on the 4th June, 1931. Left for recess in Calcutta on the same date. Remained at headquarters.
Dr. M. S. Krishnan	.	Returned from the field on the 18th April, 1931. Acted as Curator of the Geological Museum and Laboratory from the 20th April to 31st October, 1931. Attached to the Southern Circle and left for field work in Bihar and Orissa on the 7th December, 1931.
Mr. P. Leicester	.	Reported on the Hlawgaw Low Level Lake Scheme of the Rangoon Water Supply Projects. Continued and completed his work on the Underground Water Supply of Rangoon. Remained at Rangoon.
Dr. S. K. Chatterjee	.	Returned from the field on the 25th April, 1931. Services placed temporarily at the disposal of the Department of Education, Health and Lands for a period of two months from the 1st July, 1931. Remained at headquarters.
Mr. J. B. Auden .	.	Returned from the field on the 5th July, 1931. Attached to the Northern Circle for work in the Himalayas.

MR. V. P SONDHI . Returned to Rangoon from field work in the Southern Shan States on the 22nd June, 1931. Left for recess in Calcutta on the 30th June, 1931. Attached to the Burma Circle to continue his work in the Southern Shan States and left for Burma on the 8th December, 1931.

MR. B. B. GUPTA . . Returned to Rangoon from field work in the Shwebo district on the 6th May, 1931. Left for recess in Calcutta on the 12th May, 1931. Remained at headquarters.

DR. H. L. CHHIBBER . Returned to Rangoon from field work on the 13th June, 1931. Granted leave on half average pay for 1 month from the 3rd November, 1931. with permission to prefix Sunday the 25th October and the Burma gazetted holidays from the 26th October to the 2nd November, 1931. Returned from leave and resumed duty in Calcutta on the 25th November, 1931. Left for Rangoon on the 11th December, 1931.

DR. P. K. GHOSH . . Returned from field work in Rajputana on the 5th May, 1931. Granted leave on average pay for 29 days from the 3rd August, 1931. Returned from leave and resumed duty on the 1st September, 1931. Attached to the Northern Circle to work in Jodhpur State in Rajputana and left for the field on the 18th December, 1931.

DR. M. R. SAHNI . . Returned to Rangoon from field work in the Northern Shan States on the 17th May, 1931. Left for recess in Calcutta on the 26th May, 1931. Attached to the Burma Circle and left for Rangoon to continue the survey of the Northern Shan States on the 11th December, 1931.

Chemist.

DR. W. A. K. CHRISTIE On leave.

Artist.

MR. K. F. WATKINSON . Remained at headquarters. Granted leave out of India on average pay for 3 months and 5 days combined with leave on half average pay for 29 days and study leave for 2 months from the 21st March, 1931. Returned from leave and resumed duty on the 26th September, 1931.

Sub-Assistants.

MR. D. BHATTACHARJI Returned from leave and resumed duty on the 2nd January, 1931. Attached to the Central Provinces Party and left for the field on the 5th January, 1931. Returned from the field on the 30th March, 1931. Granted leave on average pay on medical certificate for 5 months from the 7th April, 1931. Returned from leave and resumed duty on the 7th September, 1931. Attached to the Southern Circle to continue his work in the Bhandara and Nagpur districts.

Mr. B. C. Gupta	Returned from the field on the 4th May, 1931. Attached to the Northern Circle for work in north Bombay.
Mr. H. M. Lahiri	Returned from the field on the 22nd April, 1931. Attached to the Northern Circle for work in the Punjab and left for the field on the 16th December, 1931.
Dr. L. A. Narayana Iyer.	Returned from the field on the 1st May, 1931. Attached to the Burma Circle for work in the Shwebo and Katha districts and left for Rangoon on the 22nd December, 1931.
Mr. P. N. Mukerjee	Returned from the field on the 6th May, 1931. Attached to the Southern Circle for work in the Cuddapah district, Madras.
Mr. A. K. Dey	On leave.

Assistant Curator.

P. C. Roy	At headquarters.

Assistant Chemist.

Mahadeo Ram	At headquarters.

Field Collectors.

N. K. N. Aiyengar	At headquarters.
Austin M. N. Ghosh	At headquarters. Deputed to inspect the occurrence of natural gas in the Mymensingh district from the 15th to 23rd April, 1931.

Museum Assistants

D. GUPTA	At headquarters
A. B. DUTTA	At headquarters.
K. P. HARAN	At headquarters.
M. S. VENKATRAM	At headquarters.

2. The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. There was one vacancy in the grade of Assistant Superintendent.

Retrenchment.

3. During the year the financial situation caused the Government of India to appoint a Retrenchment Advisory Committee to advise on the possibilities of reduction of public expenditure. The requirements of the scientific departments were examined by the General Purposes Sub-Committee of the above Committee and in all cases drastic reductions of expenditure, meaning usually drastic reductions of staff, were recommended. The value of the researches of the Geological Survey of India in contributing to the growth of the mineral industries of India, with the consequent promotion of railways and employment, and the provision of revenues to the Central and Local Governments, has been recognised; nevertheless the Government of India has decided upon a very drastic reduction of the gazetted staff of the Department to a cadre of only 3 Superintendents, 10 Assistant Superintendents and 10 Extra Assistant Superintendents. Owing to leave due to retiring officers the full reduction will take some two years to effect, but the results in the form of a reduced amount of field work accomplished will begin to appear in the next General Report.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

4. Mr. A. L. Coulson officiated as Superintendent from the 18th April, 1931, to the 31st October, 1931, *vice* Dr. J. Coggin Brown and Mr. H. C. Jones on leave. Mr. D. N. Wadia officiated as Superintendent from the 25th March, 1931, *vice* Dr. C. S. Fox on leave. Dr. J. A. Dunn officiated as Superintendent from the 20th April, 1931 *vice* Mr. H. C. Jones on leave.

Mr. E. L. G. Clegg officiated as Superintendent from the 21st September to the 31st October, 1931, *vice* Mr. H. C. Jones on leave, and again from the 1st to the 3rd November 1931 *vice* Dr. C. S. Fox on leave.

Dr. M. S. Krishnan acted as Curator, Geological Museum and Laboratory, from the 20th April to the 31st October, 1931, and thereafter Mr. W. D. West.

Mr. G. V. Hobson acted as Palæontologist from the 26th March to the 30th September, 1931, and thereafter Mr. D. N. Wadia.

Leave.

5. Dr. J. Coggin Brown was granted combined leave out of India for seven months with effect from the 19th March, 1931.

Dr. C. S. Fox was granted leave out of India on average pay for eight months with effect from the 2nd March, 1931.

Mr. H. Crookshank was granted combined leave out of India for one year and six months with effect from the 23rd March, 1931.

Mr. G. V. Hobson was granted combined leave for eleven months with effect from the 5th November, 1931.

Rao Bahadur M. Vinayak Rao was granted combined leave for two years with effect from the 14th February, 1931, with permission to retire on the expiry of the leave.

Dr. J. A. Dunn was granted combined leave for one year, two months and twenty-four days with effect from the 10th July, 1931.

Mr. C. T. Barber was granted leave on average pay for one month with effect from the 25th September, 1931.

Mr. E. R. Gee was granted combined leave out of India for six months and twenty-five days with effect from the 20th March, 1931.

Dr. H. L. Chhibber was granted leave on half average pay for 1 month with effect from the 3rd November, 1931

Dr. P. K. Ghosh was granted leave on average pay for twenty-nine days with effect from the 3rd August, 1931.

Dr. W. A. K. Christie was granted an extension of leave on half average pay for ten months.

Mr. K. F. Watkinson was granted combined leave out of India for six months and four days with effect from the 21st March, 1931.

Mr. D. Bhattacharji was granted leave on average pay on medical certificate for five months with effect from the 7th April, 1931.

LECTURESHIPS.

6. Dr. J. A. Dunn continued to act as a part-time Professor of Geology at the Presidency College, Calcutta, till the 1st July, 1931, and thereafter Dr. Krishnan from the 1st August to the 20th November, 1931. The latter was relieved by Mr. W. D West on the 21st November, 1931.

Mr G. V. Hobson continued to act as part-time Lecturer on Geology at the Bengal Engineering College, Sibpur, till the 3rd November, 1931, when he was relieved by Mr. E. L. G. Clegg

Dr. S. K. Chatterjee acted as a whole-time Lecturer on Geology at the Forest College, Dehra Dun, for a period of two months from the 1st July, 1931.

PUBLICATIONS.

7. The following publications were issued during the year under report :—

1. Records, Vol. LXV, Part 1.
2. Records, Vol. LXV, Part 2.
3. Records, Vol. LXV, Part 3.
4. Memoirs, Vol. LVII.
5. Memoirs, Vol. LVIII.
6. Palæontologia Indica, New Series, Vol. IX, Memoir No. 2, Part IV.
7. Palæontologia Indica, New Series, Vol. IX, Memoir No. 2, Part V.
8. Palæontologia Indica, New Series, Vol. XI, Part II.
9. Palæontologia Indica, New Series, Vol. XVII.
10. Palæontologia Indica, New Series, Vol. XIX

LIBRARY.

8. The additions to the library amounted to 4,701 volumes, of which 1,318 were acquired by purchase and 3,383 by presentation and exchange.

DRAWING OFFICE.

9. The Artist, Mr. K. F. Watkinson, was in charge for six months only, being absent on combined leave for the other six months. During this period the Drawing Office was in charge of Mr. G. V. Hobson, Assistant Director. The Records, Memoirs and Palæontologia Indica issued during the year contained a total of 126 plates.

Publications.

A large number of drawings and blocks for text figures were also prepared.

A considerable amount of work has also been done in the preparation of plates for forthcoming Memoirs.

Geological maps.

10. The Geological Map of India scale 1" = 32 miles, in eight sheets, which has been in course of preparation since 1923, has been published and is on sale to the public. The work of drawing the originals required was done in the Drawing Office, but the printing by photo-lithography has been done by the Photo and Litho Office, Survey of India. Owing to the amount of fine detail and the care required in matching the colours the work has necessarily been slow, but the Photo and Litho Office are to be congratulated on the excellent results obtained.

The number of geologically coloured originals received from officers numbered 32, while 1,995 topographical sheets were received from the Director of Map Publication, and 293 were issued for departmental use.

Photographic section.

11. This section has been fully occupied with the reproduction of photographs and drawings for publication. The number of original negatives received into stock numbered 259 while 1,375 photographic prints have been made.

MUSEUM AND LABORATORY.

Staff.

12. Dr. J. A. Dunn continued as the Curator of the Geological Museum and Laboratory from the commencement of the year until the 19th April. Dr. M. S. Krishnan acted as Curator from the 20th April until the forenoon of the 31st October, and Mr W. D. West took over the duties of Curator from the afternoon of the 31st October. Babu Purna Chandra Roy was Assistant Curator throughout the year. Babus Dasarathi Gupta and Anil Bhusan Dutt continued as Museum Assistants, and M. R. Ry. K. P. Haran and M. S. Venkatram acted as temporary Museum Assistants throughout the year.

Chemist.

13. Dr. W. A. K. Christie was on leave during the year under review.

Determinative work and analyses.

14. The number of specimens referred to the Curator during the year for examination and report was 637, of which analyses, assays and other special determinations were made of 37. The corresponding figures for 1930 were 930 and 76 respectively. Chemical

work included analyses of coal, peat, lime-stone, dolerite, shale, clay, wolfram, tin, manganese, spinel, glauconite, copper-ore, quartz and others.

Donations to colleges, etc.

15. During the year under review collections of Indian minerals and rock specimens were presented to the following institutions:—

1. The Irrigation Research Laboratory, Lahore.
2. The Birisiri M. E. School, Hatshibganj, Mymensingh.
3. The McMahon Museum, Quetta.
4. The Agricultural College, Coimbatore.
5. The College of Engineering, Bangalore.
6. Allahabad Municipal Museum.
7. The Forest Research Office, Ranchi, Bihar and Orissa.
8. The Mineral Adviser to the High Commissioner for India.

In addition, the following specific presentations were made:—

1. Granite, sandstone, iron-ores, and marbles, to Major Kenny, Port Blair, Andamans.
2. Vredenburgite, to the Officiating Director of the Geological Department, Mysore.
3. Tawmawite, to Prof. A. Lacroix, Paris.
4. Hollandite, sitaparite, vredenburgite and spandite, to Prof. Schneiderhöhn, Freiberg in Breisgau, Germany.

16. In addition to the large number of specimens collected by the officers of the Department, the following important Indian specimens were received and incorporated in the collections of the Geological Survey of India:—

1. Sodium carbonate blocks, saltpetre, sea salts, rock salt, and pigments; presented by the Industrial section of the Botanical Survey of India.
2. Tourmaline crystal and pegmatite, Koderma, Hazaribagh, Bihar and Orissa; presented by Messrs. F. F. Chrestien & Co.
3. Hirmji (red ochre), Par, Gird, Gwalior State; presented by Gwalior Durbar.
4. Lucullite, Sarasani, Jodhpur State, Rajputana; presented by Superintendent of Mines and Industries, Jodhpur State.
5. Tawmawite, Jade mines, Myitkyina District, Burma. Dr. Bleeck's specimen through Prof. Lacroix and Mr. A. L. Coulson.

6. Hübnerite, cassiterite, and wolframite, Taungpila mine Tavoy, Burma; presented by Mr. S. H. Harman, Tavoy.
7. Kaolin (washed), Yinnyein, Thaton District, Burma, presented by Mr. P. Johnston, through Dr. A. M Heron.
8. Meteorite (diogenite). Tunis, presented by Prof. A. Lacroix, Institute de France, Paris.
9. 21 microscope slides of heavy minerals from Assam Tertiary rocks; presented by the Assam Oil Company.

The following foreign specimens were added to the collections of the Department by exchange:—

1. Some igneous and sedimentary rocks from Australia.
2. Anatase, adularia, and quartz, Alpe Lercheltini, Binnental, Valais, Switzerland.
3. Clinochlore, muscovite and calcite, Tunnel du Simplon, Valais, Switzerland.
4. Phenacite, San Miguel di Piracicaba, Minas Geraes, Brazil.
5. Magneto-plumbite crystals, Langban, Sweden.
6. Danburite, Piz Casanel, near Vals, Grisons, Switzerland.
7. Euxenite, Ambatofotsikely, Madagascar.
8. Tourmaline (green) in dolomite, Campo Lungo, Dazio Grande, Tessin, Switzerland.
9. Bournonite, St. George's mine, Horhausen, Rhenish Prussia.
10. Pyrrhotite crystals, Bristenstock tunnel, near Amsteg, Uri, Switzerland.
11. Kyanite and staurolite, Pizzo forno, Tessin, Switzerland.
12. Demantoid, Franscia, near Lanzada, Lombardy, Italy.
13. Errite and parsettensite, Err valley, near Tinzen, Grisons, Switzerland.
14. Titanite and quartz, Rotlaue, Bernese Oberland, Switzerland.
15. Fluorite and laumontite, Giblisbach, near Fiesch, Valais, Switzerland.
16. Binnite, Lengenbach, Binnental, Valais, Switzerland.
17. Pericline, Ofenhorn, Binnental, Valais, Switzerland.
18. Smoky quartz, Giuf valley, Tavetsch, Grisons, Switzerland.
19. Albite, Alpe Ruschuna, near Vals, Grisons, Switzerland.
20. Monazite crystals, Ambatofotsikely, Madagascar.
21. Gold, calaverite, petzite, krennerite, and coloradoite, Kalgoorlie, West Australia.

17. At the request of the Director General of Archæology in India, Dr. Cotter made, in March, an examination of the specimens of jewellery, small ornaments and utensils, and statuary in the Museum at Taxila.

The stone statues were mainly of schist, both hornblende-schist and mica-schist being common. One sandstone statue was clearly from the Siwalik sandstone.

Smaller statuary, and small ornaments and utensils were usually of soapstone, shell, calcareous tufa, shelly limestone from the Giumal series, marble, and alabaster.

The jewellery consisted mainly of rock-crystal, amethyst, chalcedony, carnelian, sard, agate, onyx, jasper, malachite, lapis lazuli, and jade.

There were several boulders of gneiss, including hornblende-gneiss, which probably came from the Indus, and which may have been used for weights. One specimen of cerussite was found. There were several glass ornaments.

18. In the Rangoon Office, Mr. L. R. Sharma continued his duties as Chemical Assistant to the Burma Party. Up to November,

Rangoon Office.

1931, 44 specimens were received and reported upon, out of which 11 were quantitatively determined They included limestones, lead- and zinc-ores, and rocks from the Shan States and the Yamethin and Monywa districts, brine from Myitkyina district, and marsh gas from the Pegu district.

In addition to his duties as Chemical Assistant, Mr. Sharma held charge of the Museum collections, and upwards of 75 specimens were added to the registers by various members of the Party. A series of minerals were presented during the period under report by the Mawchi Mines, Limited.

During the period under report the Office of the Burma Party was equipped with a dark room, and a camera for micro-photography was installed. Mr. Sharma made various micro-photographs of rock slides and printed the photographs required by certain members of the Party.

Early in November, 1931, the Office of the Burma Party was moved from the building in Dalhousie Street, occupied since 1924, to more commodious premises situated in the Old Hanthawaddy Court, 593, Merchant Street, Rangoon.

PETROLOGY.

Origin of ultra-basic lavas: Kathiawar, Bombay.

19. During the field seasons 1924-25 and 1925-26 Mr. West paid two visits to Kathiawar to examine the cores of rock obtained by boring through the Deccan trap. In all, five deep borings were examined in detail, and specimens were collected for more careful study at headquarters. For various reasons work on these rocks has been delayed. But as the task of examining some hundreds of rock slides, both under the microscope and on the Federov universal stage, now approaches completion, some of the conclusions reached may be briefly summarised.

The situation, depth, and other details of the borings were given in the General Reports for the above mentioned seasons and need not be repeated here. It is sufficient to say that forty-eight flows and several volcanic agglomerates were penetrated by the three borings examined in detail, the flows having an average thickness of rather more than 39 feet. The first preliminary examination showed that the rocks penetrated by the borings at Jamnagar and Khambhalia were confined to what may be described as the 'normal' type of Deccan trap, consisting of labradorite, enstatite-augite, iron-ore and glass, resembling closely the rocks described by myself from Bhusawal.[1] But the rocks penetrated at the other three places were found to include, in addition to basalts of the normal type, many flows much more basic in composition. For that reason attention has for the time being been confined to the rocks penetrated by those three borings, situated at Dhandhuka, Botad and Wadhwan Junction.

In classifying these basic and ultra-basic lavas, Mr. West has found it convenient to divide them into four main groups, based on the nature of the phenocrysts. It will be shown subsequently that this classification has also a genetic significance. The grouping is as follows:—

1. Flows with phenocrysts of fresh olivine and augite—
   (*a*) Oceanites and ankaramites (with groundmass felspar).
   (*b*) Limburgites (with no felspar).
2. Flows with phenocrysts of fresh olivine, augite and bytownite.

[1] *Rec. Geol. Surv. Ind.*, LVIII, pp. 93-240, (1925).

3. Flows with phenocrysts of augite, labradorite and occasional altered olivine.
4. Flows with phenocrysts of labradorite and occasional altered olivine.

The phenocrysts of olivine and augite in groups 1 and 2, and of augite in group 3, are all large and very fresh. Group 4 is the normal type of Deccan trap basalt, and group 3 is very similar but contains a few of the large phenocrysts of augite that are characteristic of groups 1 and 2. Group 3 is important, therefore, in linking together the ultra-basic types of groups 1 and 2 with the normal type of group 4. Five new complete analyses have been made, which reflect the mineralogical composition as outlined above. Thus a flow from group 1 (*a*) has 43·45 per cent. of silica and 18·18 per cent. of magnesia. In a flow from group 1 (*b*) the magnesia has risen to 20·05 per cent. It is interesting to note that in this area of Deccan trap, in which special types have been evolved locally, the 'normal' type of basalt has a composition more akin to basalts of the 'central' type than to basalts of the 'plateau' type. This is shown by the high alumina (16·88 per cent.), low silica (47·90) and low total iron, in which the ferric and ferrous oxides are not very different in amount (4·80 per cent. and 5·97 per cent.).

In discussing the origin of these ultra-basic types, certain conclusions seem to be well founded. In the first place there is little doubt that all the rocks represent flows, and that none are intrusions. The various types summarised above were extruded one after the other without regard to order, and it is clear that the magmas responsible for each rock type must have been available for tapping throughout the whole time that eruption was proceeding. At Wadhwan Junction, the earliest flows, resting on the Upper Cretaceous, belong to group 1. At the other two places the lowest flows were not reached by the borings. Then again, although it is convenient to group the rocks into the four main groups given above, there is a certain amount of gradation between each group. And so the conclusion seems warranted that the various rock types must have had, ultimately at any rate, a common origin. The parent rock can scarcely have been other than the 'normal' type of Deccan trap basalt, which so overwhelmingly predominates throughout India, and which varies so little in chemical composition. This conclusion being accepted, it is profitable to discuss in what way the

ultra-basic types have been derived from the parent Deccan trap basalt.

Two processes of differentiation by crystallisation can be considered. At the end of the Cretaceous there must have been a general rise of the geo-isotherms throughout this part of the world, to cause the immense outpouring of lava that characterised those times. Locally, or during intervals of quiescence there may have been opportunity for the settling of early formed crystals, more especially olivine, and perhaps pyroxene and labradorite as well; and such aggregates, on extrusion would provide rock types of composition similar to the ultra-basic rocks described above. On the other hand, it may be that the primitive basalt had already undergone differentiation locally long prior to Cretaceous times. Subsequently, when remelting took place at the end of the Cretaceous, rock types of varied composition would be available for extrusion.

The former explanation may, on the face of it, seem the simpler. But there is a large mass of evidence which points to the second explanation being the correct one. The reasons may be stated briefly.

Mr. West has made a careful study of the optical properties of all the phenocrysts. As regards the olivines, it is clear that the composition of the crystals is closely related to the composition of the rock in which they occur. In the ultra-basic rocks the olivines are highly magnesian, that is, rich in forsterite and poor in fayalite. But in the 'normal' type of Deccan trap basalt, as determined in rocks from various parts of India including Kathiawar, the olivines are much more ferruginous. As regards the pyroxene, it is well known that in the plateau basalts this mineral falls within the limits of composition of enstatite-augite or pigeonite, a variety poor in lime and with a low optic axial angle. But in the ultra-basic rocks that are being considered the pyroxene is one of high optic axial angle, and quite distinct from enstatite-augite. Finally, as regards the felspar phenocrysts of group 2, instead of their being labradorite, which occurs exclusively in the usual Deccan trap basalt, they correspond to bytownite and anorthite in composition, a variety never found in the 'normal' basalt. Hence it is clear that these ultra-basic rocks cannot have been formed by the sinking of crystals in liquid basalt, followed soon after by extrusion. It is true that the composition of the crystals might change during sinking, but any change that took place would be in the direction of the olivines

becoming more ferruginous, the pyroxenes probably more ferruginous, and the felspars more sodic, in accordance with the laboratory determination of the course of crystallisation of those minerals. But to obtain the rock types under discussion the reverse would have to take place. The fact that the composition of the phenocrysts is so closely related to the bulk composition of the rock in which they occur makes it clear that these ultra-basic rocks must have crystallised from melts of their own composition. And so one is driven to the conclusion that there must have been available ultra-basic rock or magma in association with the predominating basalt long prior to the great outbreak of igneous activity which occurred at the end of the Cretaceous.

The importance of Mr. West's observations on these Kathiawar lavas will be manifest to all those who are familiar with the views of the modern school led by Bowen[1] in accordance with which the formation of ultra-basic rocks is attributed to the settling of early-formed crystals. I have myself arrived at conclusions similar to those of Bowen in my study of the suite of 'normal' basalts of Bhusawal. In certain of the flows of Bhusawal phenocrysts of both olivine and labradorite have sunk towards the bases of the flows since their extravasation. From this I deduced that such a process operating intra-tellurically within a porphyritic magma prior to eruption might lead to the formation of such ultra-basic rocks as peridotite and troctolite; and attention was drawn to the chromiferous peridotite laccolites of Baluchistan as possible examples of peridotites of Deccan trap age formed in this manner.[2] Mr. West has not yet examined the olivines of the Baluchistan peridotites: this he proposes to do and it will be of great interest to see whether they prove to have the optical properties proper to olivine crystals that have sunk from a basalt magma of the 'normal' type as exemplified by the Bhusawal lavas, or other optical properties such as those pertaining to the olivines of the ultra-basic lavas of Kathiawar.

20. All petrologists are familiar with the views held by Professors Daly and Shand that the nepheline-bearing rocks have been formed by the interaction of either basaltic or granitic magma with limestone. Daly has recognised that this process involves the

Origin of nepheline-bearing rocks: Mogok, Burma.

[1] 'The Evolution of the Igneous Rocks', p. 160, (1928).

[2] *Rec. Geol. Surv. Ind.*, LVIII, pp. 207, 208, (1925).

accompanying formation of lime-silicates and he supposes that these relatively heavy minerals sink to the bottom of the magma reservoir. This is an ingenious way of avoiding explaining the absence of complementary calc-silicate-rocks in association with nepheline-syenites. In spite of this explanation this absence of calc-silicate-rocks has proved a fundamental stumbling block to the present writer. In the Archæan terrain of the Central Provinces, where there is an abundance of marble both calcitic and dolomitic, no nepheline-bearing rocks have been found in spite of the presence of abundant intrusive granite. On the other hand calc-silicate-rocks (diopsidites) are abundant. It is impossible, therefore, for students of the Archæan terrain of the Central Provinces to avoid being sceptical concerning the validity of the hypothesis that ascribes the origin of the nepheline-bearing rocks to the absorption of limestone by igneous magmas.

The account recently given by Dr. Tilley[1] of the production at Scawt Hill, Co. Antrim, Ireland, of basic alkali-rocks containing nepheline and melilite, by the assimilation of chalk by basaltic magma, has been welcomed by Shand[2] as affording support to the assimilation hypothesis, especially as a complementary lime-augite is also present. Prof. Shand's heart will be further gladdened by the discovery, described on pages 94 and 95 of this Report, by Mr. A. K. Banerji in the Ruby Mines tract of Burma of a nepheline-bearing rock, containing also the complementary diopside, formed at the contact of a 6 to 8-foot vein of felspar-rock, mostly albite, with the Archæan marble into which it is intruded. As at Scawt Hill the complementary lime-silicate has not been removed from the scene of the reaction and this occurrence also seems to illustrate the same point as the Scawt Hill occurrence, namely 'the restricted potentiality of igneous magma to generate alkali types by assimilation '[3]. What happens if the intrusive is an acid quartz-bearing rock with a potash-felspar is exemplified by another occurrence described by Mr. Banerji in which a granite-pegmatite vein several feet thick in contact with limestone produces a contact zone less than a foot thick composed of scapolite, diopside, felspar, and calcite. Similar cases are common in the Chhindwara district of the Central Provinces.

[1] *Mineralogical Magazine*, XXII, pp. 439-467, (1931).
[2] *Geol. Mag.*, LXVIII, p. 288, (1931).
[3] C. E. Tilley, *loc. cit.*, p. 467.

PALAEONTOLOGY.

21. Mr. D. N. Wadia continued to fill the post of Palæontologist up to the 25th March, 1931. Mr. G. V. Hobson held charge from the 26th March to the 30th September, when he was relieved by Mr. D. N. Wadia. Field-Collector N. K. N. Aiyengar assisted the Palæontologist with routine museum work and with the determination of specimens during the year. Museum-Assistant K. P. Haran continued the work of cleaning and replacing labels in the large Klipstein Collection stored in the Invertebrate Fossil Gallery. Museum-Assistant M. S. Venkatram was engaged in routine work connected with Palæontology.

22. During 1931 the following memoirs have been published in the *Palæontologia Indica* :—

(1) L. F. Spath: 'Revision of the Jurassic Cephalopod Fauna of Kachh'. Parts IV and V of Memoir No. 2, Vol. IX of the New Series.

(2) B. Sahni: 'Revisions of Indian Fossil Plants: Coniferales (b. Petrifactions).' Part II of Vol. XI of the New Series.

(3) F. R. Cowper Reed: 'New Fossils from the Productus Limestones of the Salt Range, with notes on other species.' Vol. XVII of the New Series.

(4) F. R. Cowper Reed: 'Upper Carboniferous Fossils from Afghanistan.' Vol. XIX of the New Series.

The following papers of palæontological interest have appeared in the Records :—

(1) 'Notes on some Jurassic Fossils from the Northern Shan States,' by F. R. Cowper Reed. (Vol. LXV, pt. 1).

(2) 'Note on a specimen of the genus *Maclurites* from the Ordovician of Burma,' by F. R. Cowper Reed. (Vol. LXV, pt. 3).

(3) 'Supplementary Note on Revisions of Indian Fossil Plants, Part II Coniferales (b. Petrifactions), 1931,' by B. Sahni. (Vol. LXV, pt. 3).

The following papers of palæontological interest are in the Press, and are expected to be published in 1932 in the *Palæontologia Indica* :—

(1) G. E. Pilgrim: 'The Fossil Carnivora of India.' Vol. XVIII of the New Series.

(2) F. R. Cowper Reed: 'New Fossils from the Agglomeratic Slate Series of Kashmir.' Vol. XX of the New Series.

(3) B. Sahni: '*Homoxylon rajmahalense*, gen. et sp. nov., a fossil angiospermous wood, devoid of vessels, from the Rajmahal Hills, Behar.' Memoir No. 2, Vol. XX of the New Series.

(4) B. Sahni: 'Petrified *Williamsonia* (*Williamsonia sewardi*, sp. nov.) from the Rajmahal Hills.' Memoir No. 3, Vol. XX of the New Series.

(5) Von Huene and C. A. Matley: 'The Cretaceous Saurischia and Ornithischia of the Central Provinces of India.'

Vertebrates.

23. The plates required for Mr. A. T. Hopwood's memoir on fossil Indian Proboscidea are nearly completed, and the memoir itself is approaching completion.

In order to decide the question whether the interesting ossiferous conglomerate of Piram Island (Gulf of Cambay) is of the Middle or Upper Siwalik age Rao Bahadur M. Vinayak Rao, assisted by Mr. P. N. Mukerjee, was deputed to collect evidence, if any. Owing to the very fragmentary nature of the fossils obtained, no fresh light has been thrown on this question.

Invertebrates.

24. The types of the fossils described in the paper 'Upper Triassic Fossils from the Burmo-Siamese Frontier'[1] by J. W. Gregory, J. Weir and F. Trauth have been returned to the Department

The types of fossils described in Pal. Ind. Ser. XV, Vol. 4, Fasc. 5, 'Additional Notes on the Fauna of the Spiti Shales' by Miss Paula Steiger, have also been returned.

The duplicate as well as the field collections of fossils in the Invertebrate Gallery are being rearranged in a more systematic order so as to be more useful for ready reference and comparison.

The cleaning and relabelling of the large Klipstein Collection has progressed considerably during the year and it is hoped that this will be completed before March 1932.

Our collection of type fossils, now numbering 15315, is being carefully checked and an improved method of storage is being introduced.

Important additions to our knowledge of the Palæozoic faunas of the Federated Shan States have been made during the year under

[1] *Rec. Geol. Surv. Ind.*, LXIII, pt. 1, (1930).

review. In the last General Report [1] reference is made to the determination by Dr. Cowper Reed of the age of the lead-bearing rocks of Bawzaing (20° 57′ : 96° 49′) as Ordovician. The fossils then known from the locality included :—

Orthis aff. *testudinaria.*
Lophospira sp.
Cycloceras or *Sphyradoceras* sp.

Further collections, which have now been determined by the same authority, enable the list to be extended as follows :—

Orthis (*Dalmanella*) *emancipata.* sp. nov.
Orthis cf. *testudinaria,* Dalm. var. *shanensis,* Reed.
Orthis cf. (*Marionella*) *typa.* Bauer.
Lophospira cf. *bantatsuense,* Kob.
Lophospira cf. *elevata,* Ulr. and Scot.
Helicotoma cf. *tamurai,* Kob.
Helicotoma sp.
Cyrtolites aff. *nodosus,* Salt.
Hyolithes ? sp.
Cycloceras sp.
Ogygites cf. *yunnanensis,* Reed.
Pliomera sp.

As most of these species have not been discovered in Burma before they indicate a new fauna of the Ordovician and suggest by their affinities the Upper Ordovician.

Determinations of fossils from the Ye-o-sin locality (20° 54′ : 96° 42′) have enabled Dr. Cowper Reed to state that these beds may probably be correlated with the Lower Naungkangyi, as several of the species seem identical. The list is as follows :—

Orthis irravadica, Reed.
Orthis (*Nicolella ?*) *prætor,* Reed.
Orthis cf. *laurentina,* Billings ?
Orthis (*Dinorthis*) cf. *porcata* McCoy.
Orthis (*Scenidiella,*) *consignata* subgen. et sp. nov.
Ptychoglyptus shanensis, sp. nov.
Leptelloidea yeosinensis, sp. nov.
Sowerbyella ? aff. *youngiana* (Dav.).
Sowerbyella ? cf. *ledetensis* (Reed).
Petroria cf. *rugosa,* Wilson ?

[1] *Rec. Geol. Surv. Ind.,* LXV, p. 21.

Parastrophia cf. *hemiplicata* (Hall).
Protocrisina cf. *ulrichi*, Bassler.
Rhinidictya cf. *nitidula* (Billings).
Batostoma ? sp.
Caryocrinus cf. *turbo*, Bather.
Caryocrinus sp. a.
Caryocrinus sp. b.
Crinoid stem joints.
Primitia sp.

The Orthoceras Limestone of Tethun has so far only yielded such poor and doubtful specimens that Dr. Cowper Reed hesitates to suggest its age, though if *Endoceras* sp. really occurs, as may be the case, an equivalent of the Trenton is probably present in this part of Mawson.

From the Purple Slates of Panghkawkwo (20° 55′ : 97° 38′), which underlie the Graptolite beds of the same locality, Dr. Cowper Reed has identified the following :—

Pliomera (*Eucrinurella*) *insangensis* Reed.
Caryocrinus ? sp.
Hyolithes ? sp.

These point to the Upper Naungkangyi.

From a well-marked horizon that overlies the Pindaya beds on the west (Sheet 93 D/9), Mr. Sondhi collected large numbers of graptolites, some of which have been examined by Miss Elles and provisionally determined as :—

Monograptus cyphus.
Orthograptus vesiculosus.
Climacograptus medius.

At Panghkawkwo, near Loilem, Dr. Coggin Brown found another richly fossiliferous graptolite horizon containing *Monograptus sedgwicki* (or *priodon*), but according to Miss Elles two horizons or zones are represented amongst the specimens from Panghkawkwo. Thus, as Dr. Cowper Reed points out, it would appear that there exist in these localities the same graptolitic horizons as at Pinghsai and Ngaitao in the Northern Shan States as previously identified by Miss Elles.[1] But the specimens collected by Mr. Sondhi are undoubtedly Lower Valentian.

[1] Reed: 'Suppl Mem. Ordov. Silur. Foss., N. Shan States', *Pal. Ind.*, N. S., Vol. VI., Mem. No. 1, pp. 69-71, (1915).

Other Silurian localities include a bed near bridge 378 on the Heho-Nannoi railway section, where *Orthis* (*Dalmanella*) *elegantula* Dalm. and *Proteus* sp. occur, and purple shales near Loilem containing the coral *Palaeocyclus* sp. The former of these two may be Llandovery or Wenlock (Namhsim Beds).

From a series of thinly bedded limestones and shales amongst the dolomites of the Plateau Limestone at Na Hkyam (97° 45′ : 23° 17′), Dr. M. R. Sahni obtained a fauna showing characters totally distinct from any previously discovered in this formation. The fossils he has identified are as follows:—

Xenaspis carbonaria, Waag.
Nannites cf. *hindostanus*, Dien.
Nannites sp.
Ammonites sp.
Naticopsis (3 species).
Naticopsis cf. *khurensis*.
Platyceras sp.
Neritomopsis sp.
Holopella cf. *trimorpha*, Waag.
Murchisonia sp.
Trochus sp.
Pleurotomaria sp.
Schizodus sp.

The association of ammonites and gastropods in this fauna is unique. *Xenaspis carbonaria* Waag. is a Productus Limestone form. *Holopella trimorpha* comes from the same beds. On the other hand the genus has never been previously recorded from rocks older than the Lower Trias.

With the exception of a few specimens found in the Red Beds at Kalaw this locality has yielded the first ammonite genera discovered in Burma. Another noteworthy point is the complete absence of brachiopods, which constitute the dominant element in the Plateau Limestone faunas hitherto discovered.

In rocks of the pre-Devonian slate series of Hundwara and the Lolao valley of Kashmir, suspected by Bion to be of older Palæozoic age, Mr. D. N. Wadia has discovered at three or four localities a fauna of trilobites and primitive brachiopods that indicates a probable Cambrian or Cambro-Ordovician age. The fossils that have been provisionally identified are: *Hyolithes*, *Agnostus*,

Conocoryphe, ? *Paradoxides*, and several *Olenid* trilobites, together with *Lingulella*, *Obolus*, and some badly preserved brachiopods, with black chitinous or corneous shells, and suggesting *Discinolepis*. The slaty matrix of the fossils has undergone an imperfect cleavage oblique to the lamination, a circumstance that has in a good many cases destroyed the fossil structures.

Mr. E. L. G. Clegg, during a period of study leave in Vienna, took up the examination of Tertiary echinoids collected by officers of the Department in Persia. This collection had previously been tentatively examined by Dr. Pilgrim and the generalisations drawn from that examination were confirmed. The specimens from the Fars series include many of the species described by Duncan and Sladen from Sind and Kachh and the Mekran coast, whilst the new species discovered show affinities either with the same species or with recent species still extant; the older Tertiary specimens show affinities with those from the older Tertiary rocks of Egypt and the Cretaceous forms with forms of a similar age from western Europe. In all, about 14 new species or varieties have been described by Mr. Clegg and it is hoped that these descriptions will later be published.

Dr. Othmar Kühn of the Natural History Museum, Vienna, examined the Rudistes from the same collection and the results of his examination are published in this part of the *Records*.

A large collection of fossil invertebrates, mostly lamellibranchs and gastropods from the post-Eocene beds of Quilon, Travancore State, was despatched to Mr. A. K. Dey in London for study.

A fairly representative assemblage of Gondwana and Tertiary woods of India and Burma was sent to Mr. H. Crookshank for study in England.

In connection with the correlation of the Jurassic ammonites of Kachh, two consignments of ammonites recently obtained from the Jurassics of different parts of India and Baluchistan were despatched to Dr. L. F. Spath of the British Museum, London, for examination and comparative study.

Reference was made in the General Report for 1927 (*Records*, LXI, p. 21) to certain obscure fossils from the Vindhyans of Neemuch, and to the division of palæontological opinion, so that on one hand they were regarded as brachiopods related to the Cambrian *Acrothele*, and on the other as possibly plant remains. A few specimens submitted for opinion to Dr. F. Chapman, Palæon-

tologist, National Museum, Melbourne, are regarded by him as sufficiently well defined to justify definite description. Professor Chapman has accordingly figured and described this fossil as *Neobolus minima*, sp. nov., and suggests comparison with *Neobolus warthi*, Waagen, from the Cambrian of the Salt Range. An additional supply of specimens has been sent to Professor Chapman for study.

Dr. C. S. Fox, during his visit to the Garo Hills, Assam, last year, collected *Nummulites* from two new localities, one at Upper Siju and the other in the Simsang valley. These fossils have been despatched to Lt.-Col. L. M. Davies for his opinion as to their age.

The following fossils were sent on loan for study:—

The type specimen *Sunetta vethama*, Cott. to Mr. L. R. Cox of the British Museum (Natural History), London:

Six duplicate specimens of *Cyathophyllum multizonatum*, Reed, to Dr. H. D. Thomas of the British Museum (Natural History), London.

The help of our Museum was requested by the Victoria Museum, Karachi, for identification and naming of a large collection of fossils and recent molluscan shells. The fossils included several subdivisions of the animal and plant kingdoms. The examination of the recent shells, which consisted mainly of gastropods and lamellibranchs was kindly undertaken by the Zoological Survey of India. The fossils and the recent shells were all returned to the Karachi Museum after such determinations of the specimens as were possible.

Facilities were given by this Department to Messrs. L. Rama Rao, Assistant Professor of Geology, Mysore University, and T. N. Muthuswamy, Lecturer, College of Engineering, Madras University, to work out their collections of fossils in the Museum.

Plants.

25. A few of the fossil plants collected by Mr. N. K. N. Aiyengar in the Rewa Gondwana basin near Chicharia have now been examined by Prof. A. C. Seward. He finds that the specimens are largely varieties of *Thinnfeldia* and that one at least is a new species, which he has called *Thinnfeldia sahnii* after Prof. Sahni. Prof. Seward has further expressed his agreement with the view previously put forward by Prof. Sahni that *Danaeopsis hughesi*, Feist., is a gigantic *Thinnfeldia* and he thinks the name *Thinnfeldia* may now be applied to it. In considering these plants Prof. Seward was led to believe that the

specimens came from Parsora. In fact they were collected six miles north of Parsora from the village Chicharia, the fossil horizons of the above two places being regarded by Dr. Fox as different. The complete collection of Chicharia plants is, therefore, being sent to Professor Seward in the hope that they may throw light upon the relationship of the Chicharia and Parsora beds to each other. It may be mentioned here that Lower Gondwana fossils like *Schizoneura* and *Glossopteris*, which occur in the Pali beds at Daigaon, also in Rewah, have not so far been found associated with the fossils of the above two localities.

At the request of Prof. T. G. Halle, Naturhistoriska Riksmuseum, Palæobotoniska Avdeln, Stockholm, the type of the plant fossil *Ottokaria bengalensis*, Zeiller, was sent to him in order to enable him to determine by his new method of investigation whether its fructification is really seed-bearing or is instead microspore-bearing. He is of the opinion that the preservation of the Indian specimen proved to be unsuitable for microscopical examination, and he did not find any spores.

Some carbonaceous shales with one or two imperfect impressions of plant remains were sent by the Superintendent, Mineral Survey, Jammu and Kashmir, to this Department for the determination of the age of the coal with which they were associated. The specimens were too fragmentary for precise determination. However the impressions appear to be those of dicotyledonous plants and suggest a Tertiary age; pending better evidence a Lower Tertiary age might be assigned to the coal beds.

While on study-leave at Cambridge in June, 1931, Mr. E. R. Gee examined a number of carbonised plant fragments which he had obtained from a band of red clay-shale intercalated within the massive rock-salt of the salt mine at Jatta (33° 20′. 71° 17′), Kohat district, North-West Frontier Province. Many of these fragments exhibited a definite cellular structure, the xyloid vessels (with numerous, minute, simple pits arranged in spirals) being definitely comparable to those met with only in the wood of certain Angiosperms. This opinion was corroborated by Prof. A. C. Seward and Dr. T. M. Harris. Such evidence indicates that the age of the Salt Marl deposits of the Kohat district is not older than late Mesozoic. Bearing in mind the age of the massive gypsum zone which overlies the Salt Marl, and which has been proved—palæontologically—to be of Lower Tertiary age, Mr. Gee—in conjunction with A. B.

Wynne, Sir Edwin Pascoe, D. N. Wadia and L. M. Davies—is of the opinion that the Salt Marl of the Kohat district represents a phase of sedimentation in early Tertiary times.

Donations.

26. In response to our request, Lt.-Col. L. M. Davies has very kindly presented to this department the types and some duplicate fossils from the Samana Range described by himself, Ethel D. Currie, Helen M. Muir-Wood, L. R. Cox, L. F. Spath and J. W. Gregory in the Memoir 'The Fossil Fauna of the Samana Range and some Neighbouring Areas' (*Pal. Ind.*, New Ser., Vol. XV, Parts I-VIII).

During the year under review presentations of fossil specimens were made to the following institutions:—

Royal School of Mines, South Kensington, London.—A fairly numerous collection of invertebrate fossils from the Gaj, Nari and Khirthar stages from North-Western India, through Prof. Morley Davies. (In exchange.)

Preussische Geologische Landesanstalt, Berlin.—A collection of Gondwana plant fossils from the duplicate collection through Prof. W. Gothan. (In exchange.)

Patna College, Patna.—A collection of 101 invertebrate and plant fossils representing various sub-divisions of the animal and plant kingdoms from various parts of India and Burma.

Biological Laboratory, St. John's College, Agra.—A collection of 31 representative fossil vertebrates from the Tertiary beds of India, Burma and Baluchistan.

Department of Zoology, Presidency College, Madras.—A fairly representative collection of fossils, both vertebrates and invertebrates, from various horizons of India and Burma.

In addition to those previously mentioned, donations of fossils or casts of fossils were received either by presentation or by exchange from the following institutions:—

British Museum (Natural History), Geological Department.—Six specimens of vertebrate fossil casts of *Samotherium boissieri*, Major (one cranium and mandible), *Paraceratherium bugtiense*, Cooper (one cranium and mandible), *Lutra* cf. *sivalensis*, Lyd. (Pm_4), *Lutra sivalensis*, Lyd. (cranium) and *Canis cautleyi*, Bose (left mandibular ramus). (By exchange through Mr. A. T. Hopwood.)

Preussische Geologische Landesanstalt, Berlin.—20 specimens of fossil plants from the German coalfields. (By exchange through Prof. W. Gothan.)

Perth.—About 30 Permo-Carboniferous fossils from Western Australia. (By exchange through Mr. E. D. C. Clarke.)

Peabody Museum of Natural History, Yale University, New York.—23 fossil vertebrates and 7 casts of Eocene mammalia. (By exchange through Prof. C. Schuchert.)

STRATIGRAPHY.

27. One of the reasons that rendered it necessary to undertake a resurvey of the Salt Range was the vexed question of the age of the Salt Marl. Much light has now been thrown on this problem by the discovery by Mr. E. R. Gee of the following foraminifera *in situ* in the Marl, the identifications being due to Lt.-Col. L. M. Davies: *Dictyoconoides conditi*, *D. haimi*, *D. newboldi* var., *Siderolites miscella*, *Nummulites* cf. *mamilla*. The first four of these species are characteristic of the Ranikot stage. The age thus indicated for the Salt Marl agrees very well with that assigned on palæontological grounds to the salt of Bahadur Khel in Kohat district by L. M. Davies and D. N. Wadia.[1]

Age and origin of Salt Marl, Punjab.

It will be recalled that A. B. Wynne and others regarded the Salt Marl as older than the Cambrian Neobolus beds, which overlie it (the Purple Sandstone intervening) at Khewra. Sir E. H. Pascoe, following up the views of E. Koken, F. Noetling, and Sir T. H. Holland has, however, advocated the view that the Salt Marl is Tertiary, regarding its position under the Purple Sandstone and Neobolus beds as abnormal. Dr. G. de P. Cotter[2] in his Presidential Address to the Geology Section of the 18th Indian Science Congress, reviewed the evidence for both views, and summed up somewhat in favour of a pre-Cambrian age. In a foot-note (p. 300) written after he had examined the Khewra occurrence of nummulites discovered by Mr. Gee, and had decided that they were *in situ*, he favoured an early Tertiary age for the Marl, or, if the nummulites were derived, an age later than early Tertiary. He also suggested an intrusive origin for the Salt Marl. Mr. Middlemiss[3] many years ago referred

[1] *Trans. Min. and Geol. Inst. Ind.*, XXIV, p. 202, (1929).
[2] *Proc. Eighteenth Ind. Sci. Congr.* (*Asiat. Soc. Beng.*), pp. 297-300, (1931).
[3] *Rec. Geol. Surv. Ind.*, XXIV, pp. 19-42, (1891).

to the [illegible] *post*-intrusive relation of the Salt Marl to other formations and [illegible] the possibility that it was intruded or injected in later times into its present position in the Salt Range. [illegible] explain the source of this hypothetical intrusive and [illegible]

[illegible] might picture to ourselves as [illegible] partly resulted from [illegible] changes in the overlying [illegible] strata.

Mr. Gee, however, [illegible] that the field evidence definitely indicates that the Salt Marl [illegible] intrusive phenomena, a deposit *in situ* in the Salt Range.

EARTHQUAKES

28. In the early hours of Tuesday, the 25th of August, 1931, between 3-0 a.m. and 3-15 a.m. the inhabitants of Quetta were suddenly awakened by a sharp shock which was followed some two minutes later by another shock of similar intensity. A number of tremors followed throughout the succeeding [illegible] hours, leading up to the most severe shock of all at 8-51 p.m. (Indian standard time) on Thursday the 27th. This was followed for some weeks by a large number of aftershocks of varying intensity which gradually decreased in both number and severity [illegible] the 19th quite an appreciable [illegible]

Baluchistan

Upon receipt of the [illegible] of August the 25th Mr. West was deputed to carry out an examination of the disturbed area and he arrived at Quetta on the evening of the 31st August. The fact that the railway line along the Harnai route to Quetta was open again for traffic four days after the main shock shows that the reports of damage as published in the press were much exaggerated. The other route through the Bolan Pass was not open until two or three days later. But the delay here was due not so much to damage to the track itself as to the fall of large boulders of rock on to the track from the precipitous hillsides that overhang it.

29. The epicentre of the shocks that occurred on the 25th seems to have been near to Sharigh (30° 11′ : 67° 41′) on the Sind-Pishin (Harnai) branch of the N. W. railway. At this place the bazaar, built mostly of sunbaked mud, was completely ruined, while other buildings, such as the hospital and some of the railway quarters, built of sunbaked brick and mud mortar, were severely damaged.

The Sharigh earthquake of 25th August 1931.

The tremors of these shocks, though clearly felt in Quetta, were not responsible for much damage there. At Ziarat, however, a good deal of damage in the way of cracks in buildings was caused by the shocks of the 25th, these shocks and that of the 27th being felt about equally severely at this place.

The main direction of movement of the shocks of the 25th seems to have been about S.W.—N.E.

The Mach earthquake of 27th August, 1931.

30. The epicentre of the main shock, which occurred on August the 27th, must have been near Mach on the Bolan section of the N. W. Railway. This shock was felt over a large part of Baluchistan and Sind. But severe damage was mostly confined to within a short distance of Mach and to a certain extent to the alluvial tract that borders the hills to the south-west of Sibi. In new Mach and old Mach nearly all the buildings were damaged to some extent; while many buildings, built of sunbaked mud bricks or stone with mud mortar, were completely ruined, such as the two Rest Houses and the village at old Mach, and the bazaar and some of the railway quarters at new Mach. At the latter place, the new jail, completed only eighteen months before, was considerably damaged. The north wall, built of ordinary concrete, was thrown down to the south, and the south wall was badly cracked. Of the interior radial walls, those that were aligned in a S.W.—N.E. direction tended to be overthrown to the south-east. The cells, built of 'pucca' brick and mortar, were only slightly damaged. The power house was undamaged.

This shock of August the 27th seems to have lasted quite a minute and a half near the epicentre. It was just perceptible at Lahore, and rather more strongly felt at Karachi. At Quetta it was this shock that was responsible for most of the damage sustained there, consisting in the main of cracks in buildings, the partial fall of poorly made walls, and the overturning of a number of chimney pots. Some villages in the alluvial tract to the south west of Sibi were badly damaged, more especially Dadhar (built on an artificial mound), Mushkaf, Sanni and Shoran; and it was in these places that the majority of deaths occurred, through mud buildings collapsing on to the narrow alleys. In all, something like a hundred lives were lost. Another feature of the earthquake was the increase in the water supply around both Quetta and Ziarat. In the Urak valley, E.N.E. of Quetta, it increased 30 per cent., while the flow of water in the *karezes* also increased.

During the earthquake of August the 27th there is little doubt that the direction of movement changed. At the start the movement seems to have been in a N. and S. direction. But it quickly changed to an E.—W. or S.E.—N.W. direction, remaining thus throughout the greater part of the shock. It was in a S.E. direction that most objects fell. This change in direction was perhaps responsible for the rotation of one or two objects on their supports in a clockwise direction. In general the buildings that suffered most damage were those that were least homogeneous in structure, such as the railway stations built of stone blocks with only mud mortar in between. Brick buildings made of 'pucca' bricks with good mortar were much less affected: but such buildings are rather scarce in this part of India, where the small rainfall renders unbaked mud sufficient for most purposes.

In estimating the intensity of this earthquake of the 27th, data regarding the damage to buildings are a little misleading, owing to the poor manner in which the majority of buildings in this part of India are built. Thus, although at Mach nearly every building was damaged, the large power-house built of good brick and mortar, was quite undamaged; while the brick houses inside the prison were many of them undamaged. It is therefore doubtful if this earthquake can be said to have reached an intensity of IX on the Rossi-Forel scale, even at the epicentre.

31. As regards the cause of the earthquake, until all the local information has been received and classified it is not possible to point to any one particular geological feature as being responsible. It may be pointed out, however, that Quetta is situated at a position of special complexity in the mountain system of this part of India, at the apex of a large re-entrant angle in this southward-running branch of the Tertiary mountains. Between Quetta and Karachi the folding movement which has produced the Kirthar and other ranges has acted in a west to east direction; to the east of Quetta, in the Zhob-Harnai system of mountains, the movement has been towards the south and south-west; in the Bugti Hills the folds are displayed in a large curve facing south; while in the Sulaiman Hills the movement has once more been from west to east. It is as though in the general sweep eastwards the folds had been held up by some obstacle in the Quetta-Sibi area, which has disturbed the general north and south alignment of the resulting hills. Whatever the cause may have been, the rocks here are likely to be in a

condition of much greater strain than elsewhere. And the resulting movements along faults or thrusts, which must occur from time to time, will manifest themselves at the surface in the form of earthquakes. From what has been said above, it will readily be understood that this district will always be liable to earthquakes in the future as it has been in the past.

Burmese earthquakes in general.

32. The Pyu earthquakes of December 3rd and 4th, 1930, which are mentioned in the last General Report, form the subject of a Memoir by Dr. Coggin Brown and Mr. P. Leicester, which is now nearing completion. These earthquakes were followed by the usual swarm of small aftershocks which continued in various places in and about the epicentral tract up to the end of the year.

Records of many earthquakes have been received for practically every month during 1931, the more important of which may be briefly mentioned. On March 27th, about 9-15 a.m., a feeble quake which disturbed Rangoon was also reported from various places in the Pegu and Hanthawaddy districts. On May 4th, between 9-15 and 9-30 a.m., a slight shock disturbed places as wide apart as Zigon in Tharrawaddy, and Pegu. On May 16th a shock strong enough to cause startled persons to leave their houses was felt about 4-20 p.m. in Rangoon. It was reported from Pegu, Moulmein and other places in addition. Another shock, at 8-42 a.m. on May 21st, caused some alarm in Rangoon. On August 6th to 8th a series of earthquakes took place in Amherst, followed on the 10th by the Pyinmana shock at about 4-50 p.m., which was felt up and down the Samon and Sittang valleys between Mandalay and Pegu. More disturbance followed in Amherst on the 12th, 13th, 14th and 15th of August, while on the 19th of the same month Mandalay experienced a slight tremor, strong enough to cause minor cracking, at about 1 a.m. The September shocks were located between Toungoo and Pegu, but Rangoon, Prome, Henzada, Toungoo and Amherst were also affected. On November 21st at 4-50 p.m. a slight shock stopped clocks in Bassein and was noticed at various places in the Delta.

The Kamaing earthquake of 28th January, 1931.

33. At about 2-35 a.m. (B. S. T.) on the 28th January, 1931, a very violent earthquake occurred in the Kamaing sub-division of Myitkyina district. The main shock came without any preliminary warnings, lasted 30 seconds and is estimated to have attained an

intensity of IX on the Rossi-Forel scale. According to Dr. Chhibber, the town of Kamaing lies just outside the epicentral tract, but all the masonry buildings in the place were severely damaged and pagodas were destroyed. In the Lawa Tract, comprising the epicentral area, even bamboo and wooden houses, raised a few feet from the ground—types which often escape damage—were completely wrecked. Landslips and rockfalls were frequent and fissuring of alluvial ground took place. The quake was felt over the whole of the Myitkyina and the greater part of the Katha district, and was followed by numerous aftershocks.

North-East Frontier of Burma: Htawgaw.

34. The frequency of earthquakes during recent years in the North-East (Chinese) frontier of Burma suggests that this forms part of an unstable landmass. These earthquakes have of recent years been so frequent and disastrous that the necessity arose of considering the selection of fresh sites for Military Police outposts in the Htawgaw Sub-division. This work was undertaken by Dr. Chhibber between the second half of November, 1929, and the third week of February, 1930. Careful enquiries made by him from the local intelligent people and Government officials elicited the information that at least 2 or 3 and sometimes more distinct earthquakes, besides slight tremors, occurred there every year. In December, 1928 these earthquakes reached devastating intensities culminating in a very severe shock at 6 p.m. on the 19th of January, 1929, reported to be the severest shock ever felt in Htawgaw. All the stone masonry buildings at Htawgaw were so badly damaged that they were considered no longer fit for human habitation. This shock was reported by the Deputy Commissioners of Bhamo and Katha as felt in their districts also, and at least as far as Tong Yüeh in Yunnan. From the nature of the damage done to the buildings, raised almost on solid rock, Dr. Chhibber concludes that the intensity of the shock, on the Rossi-Forel scale, must have been IX. A still more severe shock occurred on the 4th of June, 1929, and much damage was done by this; other shocks were felt at intervals during June, July, August, September, and October, 1929.

During the period of his visit Dr. Chhibber collected data of several hundreds of shocks, including their apparent direction, intensity, duration and their effects at the places visited by him. The nature of the damage done by these earthquakes to buildings at Htawgaw, and the position and direction of the cracks, were carefully

studied by Dr. Chhibber in the buildings that were still standing at the time of his visit. He traversed the whole of the area between Myitkyina and Hpimaw (26° 0′ : 38° 98) and thence to the Fenshiuling Pass (25° 49′ : 98° 40′). From Htawgaw he made a hurried detour to the Lagwi Pass (25° 49′ : 98° 31′). The exact extent of this seismic belt is difficult to delineate since no careful records of the shocks were kept in the past. However, they appear to be felt throughout the Myitkyina district, as a rule, and when particularly severe are even experienced in the adjoining districts of Bhamo, Katha and the Upper Chindwin and at least as far east as Teng Yüeh in Yunnan. The Chinese Telegraph Master at Teng Yüeh wrote in December, 1929, that 'earthquakes are felt here one or two times every day since October, 1928.' The plains of Wausawng (25° 22′ 30″ : 97° 35′ 30″) seem largely to absorb the intensity of these shocks before they reach Myitkyina itself.

While Dr. Chhibber was at Htawgaw another very severe shock occurred on the 16th December, 1929, at 2-30 a.m., with an intensity of IX on the Rossi-Forel scale. Another severe one was felt again on the same date at 9 a.m. As a consequence of these, cracks developed in various places and landslips and rockfalls occurred on the Htawgaw—Hkam Hkam road, which was blocked in several places as a result. The earthquakes continued all the time Dr. Chhibber was there and are still occurring, according to the monthly reports received from the various Government officials of the area. The absence of any instrumental record of these earthquakes at Rangoon or elsewhere in Burma is greatly to be regretted. The earthquakes are generally preceded by earth sounds which have been compared to 'thundering of clouds,' 'bombardment of heavy guns,' 'rattling of trains,' etc.

35. With regard to the causes of the earthquakes, Dr. Chhibber thinks that the junction between the granite and volcanic tuffs near the Lagwi Pass is faulted, and in his opinion it is movements of this fault that are responsible for these earthquakes. It is noteworthy that on either side of the fault the direction of the earthquakes' sound is reversed. It was noted, while camping near the Lagwi Pass, that the sound did not seem to originate every time from the same spot but rather that it appeared to travel, probably indicating movement at different places at different times along the fault line. The earthquakes near the Lagwi Pass, along with the brontides, were far more frequent and severe in intensity than elsewhere, and

sometimes they appeared almost incessant. Occasionally while Dr. Chhibber was writing notes of one earthquake another one would follow, and for the three nights during which he camped near the Lagwi Pass he had practically no sleep. The depth of the focus appears to be shallow, since their intensity dies away quite abruptly.

Sometimes independent minor shocks are felt in the Kamaing sub-division of the Myitkyina district and these appear to have a seismic focus of their own. Some of the formations there are faulted, a fact further confirmed by the existence of a series of salt springs. The same fact also seems to be true of the shocks felt from time to time in the Wuntho sub-division of the Katha district.

ECONOMIC ENQUIRIES.

Alum.

Amb, N. W. Frontier Province.

36. A specimen of alum-shale was given to Dr. Cotter by the Chief Magistrate to the Nawab of Amb. This specimen is from Pandarah, 1 mile S.W. of Amb (34° 18′: 72° 51′), in the Hazara district, North-West Frontier Province. The geology of this area is not known.

Barytes.

Yawnghwe State, Southern Shan States.

37. According to Mr. V. P. Sondhi barytes is of common occurrence in the neighbourhood of Mawsôn (20° 57′ : 96° 50′), where it is frequently associated with quartz and calcite but occasionally found in well-developed veins. An outcrop of barytes was found east of Konlean (20° 48′: 96° 39′), about 5 miles W.N.W. of Taunggyi.

Bauxite.

Nandgaon State, Central Provinces.

38. In response to a request from the Ruling Chief of Nandgaon State, Central Provinces, Dr. S. K. Chatterjee was deputed to visit certain mineral deposits in that State. Amongst these was an occurrence of bauxite in a laterite capping to a hill about one mile

east of Bhabei (21° 31′ : 80° 15′), the underlying rocks being a series of grey mottled slates, epidiorite, ferruginous quartzite, and jaspilite. The hill strikes N. S. in conformity with the general strike of the rocks of the area, the lateritic capping covering an area of about 1 mile by 250 yards, with an estimated thickness of about 10 feet. The bauxite occurs in bands and irregular segregations in the laterite, the proportion of bauxite to laterite increasing in a southerly direction. An analysis of a sample of the bauxite, carried out by Mr. J R. Hutchinson of Calcutta in 1930, is reported to have yielded the following result:—

	Per cent.
SiO_2 . .	1·28
Al_2O_3	60·66
Fe_2O_3	2·50
MgO	*Nil*
CaO	*Nil*
TiO_2	10·50
Loss on ignition	25·16
TOTAL .	100·10

This deposit was originally reported on by Mr. M. Z. Abedin, a mineral prospector in the employ of Nandgaon State.

Coal.

39. Although the field work of the Coalfields Party has come to an end the results of their labours have not yet all been published. During the year two memoirs from the pen of Dr. Fox were published on 'The Natural History of Indian Coal,' and on 'The Gondwana System and Related Formations,' forming respectively Volumes LVII and LVIII of our *Memoirs*. The comprehensive scope of these two memoirs is indicated by their title. Mr. E. R. Gee's memoir on the geology of the Raniganj Coalfield is in the press and should issue shortly.[1] Dr. C. S. Fox completed his examination of the coalfields of India by visiting during January and February, 1931, the coalfields of Assam around Cherrapunji in the Khasi Hills and in the Simsang Valley of the Garo Hills. The small coalfields between Shillong and Cherrapunji are not considered to be of great economic importance, but they are nevertheless valuable for local

Khasi and Garo Hills, Assam.

[1] Since issued as *Mem. Geol. Surv. Ind.*, LXI, (1932).

purposes. Dr. Fox agrees with previous investigators (H. B. Medlicott, La Touche and others) that these coal seams belong to two geological epochs—one set to the Upper Cretaceous and the other to the Lower Tertiary.

Dr. Fox visited the Rongrenggiri and Daranggiri coalfields in the upper Simsang valley in the Garo Hills. He draws attention, however, to the greater accessibility of the seams in the neighbourhood of Siju in the Simsang valley from the plains, and especially those in the hills in several localities east of Siju and Rewak. These latter occurrences were privately examined ten years ago and that exploration has revealed the fact that the seams found on the hills known as Baljong, Dogring and Waimong contain upwards of 4 million tons of coal of good quality, whilst the Asilgaon Hill coalfield, which is a little less accessible, contains some 16 million tons of coal of similar quality. The credit for the discovery of these seams is due to Mr. Berkeley, while the geological and mining aspects of the seams have been favourably reported on by Sir Henry Hayden and Mr. C. S. Whitworth. Dr. Fox is in agreement with the favourable opinions of the coal and its location and considers that the manufacture of lime or of cement of special quality could be undertaken at some place in the plains when industrial conditions are more favourable than at present. He confirms the age of the coal as probably Upper Cretaceous and certainly pre-Sylhet limestone. The coals underlie sandstones that are overlain by the Siju limestone (proved by fossil evidence obtained by Dr. Fox to be Middle to Lower Kirthar and consequently the same as the Sylhet limestone of the Khasi Hills). Dr. Fox was unable to locate any Tertiary coal seams equivalent to those near Cherrapunji.

Meiktila district, Burma.

40. In the course of his work in the Southern Shan States Mr. V. P. Sondhi discovered several coal outcrops between the Loian coalfield (20° 38′ : 96° 37′) and Minapalaung (20° 56′ : 96° 30′). This latter place though lying on the edge of the Southern Shan Plateau, is actually within the Meiktila district. He was not favourably impressed with the commercial possibilities of these occurrences, as the coal itself is powdery, the seams dip at high angles, and the enclosing rocks are highly folded and faulted. The only locality that may be worthy of future attention lies about one mile south of Legaung (20° 49′ : 96° 32′ 30″), where three outcrops were found along the strike, all apparently belonging to the same seam. The

total thickness is nowhere exposed and the enclosing beds of clay and carbonaceous shale dip either to the west or slightly to the north of west at about 45°.

Myitkyina district, Burma.

41. A small lenticular seam of coal was found by Dr. H. L. Chhibber about $1\frac{3}{8}$th mile W.N.W. of Tarongyang (25° 40′ : 96° 45′) in the Kamaing sub-division of the Myitkyina district. It is exposed in a small water course, a tributary of the Wanga Hka. The seam is surrounded by slightly arenaceous blue compact shales, which are highly jointed and contain leaf impressions. The rocks dip W.N.W. at low angles.

The Subdivisional Officer, Kamaing, informed Dr. Chhibber that coal also occurs near Sumdukawng in the Lawa tract of his subdivision.

Copper.

Pindaya State, Southern Shan States.

42. Stains and thin coatings of oxidised copper-ores are of frequent occurrence on rocks about one mile to the south-east of Ale-chaung (21° 0′ : 96° 33′ 30″) according to Mr. V. P. Sondhi.

Yawnghwe State, Southern Shan States.

43. On the lower slopes of the western flank of the Heho range, about 150 feet above the Heho plain, in the first valley north of the one that carries the railway from Kalaw to Shwenyaung, and about half a mile from Heho (20° 43′ : 96° 52′) there are, according to Dr. Coggin Brown, an unprotected shaft, 30 or 40 feet deep, and the dumps from two or three collapsed adits. These workings appear to be in a shaley band or bands intercalated in limestones of the Heho type of Upper Ordovician or Lower Silurian age. On the dumps pieces of massive vein quartz occur which seem to indicate the presence of narrow quartz veins. Both these and the fragments of shale often contain films of malachite and azurite. Chalcocite was present in some specimens.

Ajmer-Merwara, Rajputana.

44. Iron pyrites has been recorded by Mr. B. C. Gupta in the pegmatite veins at Kerakibari (25° 45′ : 74° 14′) in the Todgarh *tehsil* of Ajmer-Merwara, in association with vein-quartz and calcite. Copper ores,—chalcopyrite, cuprite and azurite—are present, and the pyrite also contains traces of copper. This vein was struck in the course of digging a well in the gneisses, and no surface outcrop nor other occurrences in wells were found, in spite of diligent search.

15. At Dariba (27° 49′ : 74° 22′), ten miles west of Tal Chhapar Railway Station on the Degana Ratangarh section of the Bikaner State Railway, there is said to be an old copper mine. The Nazim of Sujangarh informed Dr. Heron that the Bikaner Darbar had put down a shaft or bore-hole to a depth of 220 feet through the alluvium, without result.

Bikaner State, Rajputana.

The ridge of Malani tuffs near Biramsar (28° 2′ : 74° 47′) is divided into two unequal portions by a *col* about one-third of its length from its north end. In the northern portion is a zone about two feet wide, parallel with the strike, in which green films of basic copper carbonate occur in the shear-planes of the slaty tuffs. A level has been driven for about twenty feet along this, and two pits some six feet deep sunk on it, close to the level. Near the south end of the ridge, three inclined burrows five to fifteen feet deep have been dug where copper-staining is visible. Prospecting has evidently been unsuccessful, and the occurrences are of no economic importance.

Engineering and allied questions.

16. In March, 1931, at the invitation of the Kashi Tirth Sudhar Trust, Mr. Auden visited Benares in order to study the erosion by the Ganges river of the left bank, upon which the ghats are situated. For many years the ghats have been collapsing, to the distress of the thousands of pilgrims who come annually for bathing and worship.

Collapse of bathing ghats, Benares.

The question of the influence of the Ganges on the collapse of the ghats is difficult to decide. Benares is known to be an extremely ancient Hindu city, from which it may be concluded that, from the time of its foundation up to the present day, there has always been bathing from the left bank of the river. It is not known definitely how far back, before the time of the Mahratta conquests, stone ghats had been used for this purpose. It is also unknown, therefore, if the left bank of the river, on which Benares has been built, lay originally further to the east than it does at present, and has been gradually eroded westwards. Since 1830, however, there is clear evidence that ghats built of stone have been collapsing into the river. At the present day, there is

hardly a single ghat intact, and, in the case of Mir and Scindia Ghats, the damage due to collapse has been extremely severe.

That instability exists at the present time may be seen from the fact that cement bridges, which the engineers of the Trust recently put over cracks in the stonework of Scindia Ghat, have themselves been cracked.

The causes of collapse are not clear, but Mr. Auden discusses two factors :—

(1) River erosion.

(2) Insecure foundations.

With regard to erosion, the data are not sufficient to give a definite opinion. The ghats lie on the concave bend of a river, which is the side liable to erosion. Detailed surveys by the Trust engineers have shown that the deepest water occurs along the concave side of the bend opposite Lal Ghat, while relatively shallow water occurs along the straight reaches of the river, by Assi Ghat and the Dufferin bridge. High sand banks occur opposite Lal Ghat, on the convex side of the bend. This is, of course, the usual condition seen in rivers. Once a bend originates, there is a tendency for it to enlarge on the concave side, in this case, the side upon which the ghats rest. River bottom surveys were carried on by the P. W. D. in 1921, and by the Trust engineers in 1930. In the interval of nine years between these two surveys, no regular shift of the line of deepest scour can be proved to have occurred, nor has the left bank shifted to the west. It must be remembered, however, that such a time is insignificant compared with the history of the river, or of the city itself, and it cannot be concluded that the Ganges is not slowly cutting away its left bank.

During the monsoon months, when the river is in flood there is found to be silting up on the left bank between low and high water levels, and at the same time a scouring out of the bottom of the river, below low water level. This scour is filled up partly with loose deposits during the winter months, owing to the diminished velocity and carrying power of the current The silting up of the bank between low and high water levels is doubtless due to the submerged ghats and temples acting as groynes and arresting the velocity of the current.

There would appear to be little danger, therefore, of the erosion of the bank between low and high water levels, The danger is more in the vertical and slow lateral scour which may take place

below low water level during the monsoon period. Mr. Auden suggests that in the deeper places of the bend of the Ganges river at Benares, the river may have cut down through the clay to the sand that bore-holes show to occur at a fairly constant level below the clay, namely, between 131 and 148 feet O. D. The mean low water level of the river is about 192 feet O. D., while the greatest depth for low level water is 62 feet, or 130 feet O. D., which should be well within the sand. The sand is usually dry, as was found in the bore put down at Harishchandra Ghat, being covered by impervious clay. Should the river reach down to this sand, it is possible that slip may occur along the junction plane between the two facies, particularly if the angle of rest of the sand is altered by its becoming saturated with water.

Erosion, therefore, may be responsible for slightly undermining the bank below low water level during monsoon flooding, and for reaching the sand below the clay, so as to upset its stability. The cumulative effect of undermining over a large period of years is not known, but is certainly significant.

With regard to foundations, Mr. Auden states that these are generally very inadequate. Stone steps are laid direct on clay, without protection in front, and without adequate pile or well foundations. There is a general scouring out of the clay from beneath the unprotected steps, so that these are undermined and eventually topple over. There is no doubt that many of the ghats owe their present precarious condition solely to inadequate foundation and protection. The collapse of Scindia Ghat was certainly in part due to the placing of a heavy masonry superstructure upon wooden piles, though in this case there must be subsidiary causes, since the ground is itself unstable.

The problem to be faced by the Trust turns therefore on two main issues. Firstly, there is the question of foundations. Reports have been submitted by Messrs. Cornelius and Prashad. Both engineers are convinced of the necessity of improving the foundations, though their actual proposals differ as to method. Secondly, there is the question of protection of the river bed. The scheme proposed by the engineers of the Trust is the construction of a periphery of wells and intervening sheet and screw piles in the clay with kankar to a depth below that of maximum scour sufficient to insure their stability. The ghats are to be brought forward to this periphery, which will act as a toe protection. The bed of the river

is to be left unprotected. It is impossible to predict the effect of such a construction on the scouring and silting of the river. A training wall embankment, laid on mattresses along the concave side of the Rangoon river, opposite Rangoon harbour, had the effect of causing silting up on both sides of the wall, and of shifting the deepest water towards the convex bank. It should not be argued from this that no erosion is to be expected along the off-shore side of the proposed periphery of wells and piles. Some scour may be expected, so that these piles may eventually be exposed for some considerable part of their height to the direct action of the river. If there is any outward thrust on these partly exposed piles, as a result of their overburden of steps, their stability may be endangered in those places where river erosion is active.

The point to be considered is the advisability either of protecting the present bed of the river from an erosion that may, but not necessarily will, take place, or of allowing the river possibly to erode up to the piles and hoping for their stability. Mr. Auden suggested the dropping of a loose apron of stones along the concave bank of the river from low water level down to the line of maximum scour. It should be possible, at no great expense, to bring blocks of Vindhyan sandstone down stream from the quarries at Chunar and then dump them from pontoons. The rock breaks up into slabs, which would not roll, nor slip down any except the steepest gradients, where mattress methods could be adopted. It is said, however, that the cost of such an apron would be prohibitive. Mr. Cornelius independently suggested the anchoring to the reconstructed ghats of reinforced concrete blocks linked together into mattresses. This scheme has also been condemned on account of cost.

The several reports of Messrs Auden, Cornelius and Prashad are published in booklet form in 'Benares and its Ghats'. No indication is given in the booklet as to which scheme will be finally adopted, but it is to be presumed that the question of both protection and of foundations will be reconsidered in view of the opinions therein expressed.

Bombay-Sind Connection Railway Survey.

47. During January and February, 1931, Dr. P. K. Ghosh traversed the country between Viramgam and Badin, including a portion of the Rann of Cutch, in the company of the engineers of the Bombay-Sind Connection Railway Survey, for the purpose of reporting on available building materials and water supply.

Alluvium, of course, covers nearly all this country, and varies in character from the elongated sandhills, parallel with the direction of the prevailing wind, to the mingled marine and freshwater deposits of the Rann. The alluvium carries considerable quantities of *kankar* (concretionary calcium carbonate), gypsum and salt.

The chief outcrops of solid rock are in the peninsula of Nagar Parkar in the Rann of Cutch. Of these the oldest rocks, amphibolites and dolerites, are found as inclusions in the granite and its associates. The granite occurs in two varieties, one coarse-grained and greyish, and the other finer grained and purplish. In addition there are minor veins of quartz-porphyry, felsite and aplite.

Around the foot of the granite hills and at various localities on the eastern margin of the Rann of Cutch, beds of calcareous sandstone were deposited, which, near Eval, west of Radhanpur, are intercalated with limestone. These are supposed by Dr. Ghosh to be Tertiary or Cretaceous. On the surface of these sandstones and limestones laterite is locally deposited.

The sandstones and laterite are, as a rule, too soft and cavernous for building purposes, but the granite will supply a suitable material for heavier structures on the proposed railway. The limestone and 'kankar' provide ample material for the manufacture of lime.

The most serious problem for this railway is that of water supply of a quality suitable for drinking and for use in engines. It is possible that artesian conditions may be found between the eastern margin of the Rann and Viramgam, an area in which porous rocks, such as sandstones, interbedded with certain limestones, appear near the edge of the Rann, and show a gentle but decided inclination to the S.E. and S.S.E. These pass to the eastwards under alluvium, consisting of sandy beds alternating with clayey layers, and water may be obtained both in the alluvium and in the underlying rocks, but in consequence of the inclination of the bed-rock, the further the site of the bore-hole is selected towards the south-east, the deeper will the boring require to be. This deduction is borne out by the bore-hole records of Viramgam, Sankeshwar, Sami, etc.

In the area of the Rann there is little hope of getting potable water, except in the vicinity of the granite hills of Nagar Parkar. The rain falling on them is partly absorbed by the alluvium surrounding them, and might be reached by borings and wells, but would not be under artesian conditions.

18. At the instance of the Burma Government Mr. Barber was requested to report on the alignment of the Minbu-Pakokku Railway, with the object of suggesting a modification of the alignment that would not prevent the orderly development of the leased blocks of the Minbu oilfield.

Alignment of the Minbu-Pakokku Railway, Burma.

The alignment of the proposed railway enters the demarcated blocks of the Minbu oilfield in Block 16S, but from this point to the north of Block 1S it traverses either the steeply dipping strata of the eastern limb of the Minbu anticline or newer rocks (the sands and gravels of the Irrawaddian and alluvium), neither of which offers prospects of commercial production of oil. There is, therefore, no objection to this part of the alignment as far as the development of the Minbu oilfield is concerned.

At the south of Block 2S the alignment crosses the crest of the Minbu structure and traverses for a distance of some three miles to the north the gently dipping strata of the western limb of the anticline.

Mr. Barber has shown that although a large portion of the alignment in Blocks 2S, 2N, 19P and 20P lies to the west of the limits of production in the known shallow producing sand, it does traverse territory that must be regarded as potentially productive, in view of the possibility of deeper sands being discovered.

In view of the asymmetry of the Minbu structure it is anticipated that the western limits of production in deep productive sands will lie to the west of the limits of production in the shallow sand. Owing to the absence of evidence far out in the east flank of the Minbu structure it is impossible accurately to determine the hade of the axial plane, but on the basis of available evidence Mr. Barber has estimated that at 8,000 feet the limits of production would lie approximately 1,000 feet to the west of the productive limits of the shallow sand. As with modern rotary equipment 8,000 feet is well within reach of the drill, it is proposed that a line drawn parallel to the western limits of production of the shallow sand, and 1,000 feet to the west of it, be adopted as the western limits of the drillable area.

In view of the asymmetry of the Minbu structure it is improbable that the eastern limits of production of deep producing sands would extend beyond the limits of shallow production. The eastern limits of shallow production in the shallow sand have, therefore, been taken as the eastern boundary of the drillable area.

Owing to the occurrence of a wide belt of alluvium in Blocks 19 and 20P, which obscures the geological structure in these blocks, it is very difficult to determine the northern boundary of probable production. It is thought, however, that the northern boundary of Block 19P and its projection into Block 20P may be safely regarded as the northern boundary of the drillable area.

The alignment as at present proposed traverses the drillable area, as postulated above, longitudinally, and as lessees are prevented by their mining lease from drilling within 50 yards of a railway, the construction of the latter would preclude the development of a strip of territory approximately 400 feet in width and some three miles in length. In the event of deep oil sands being discovered in this part of the Minbu structure, and this area proving productive, this would result in great loss of royalty to Government.

In view of the fact that the eastern portion of the drillable area extends into the western margin of Minbu town, it appears inevitable that the alignment shall cross the drillable area, but in order to reduce to a minimum the area in which drilling operations would be prohibited, it is recommended that the alignment should cross the drillable area as nearly as possible at right angles to its long axis.

It is presumed that the site of the bridge to carry the railway across the Sabwet Chaung has been carefully selected, and as the present proposed alignment does not encroach on the drillable area south of this point, no alteration is recommended in the alignment south of the Sabwet Chaung. It is recommended that after crossing the Sabwet Chaung the alignment be deflected as sharply as possible to the west until it passes out of the drillable area, and that from this point it be continued in a northerly direction to the west of the line marking the western limits of the drillable area. This involves deflecting the alignment some 1,000 to 2,000 feet to the west of its present line for the greater part of its course through Blocks 2S, 2N, 19P and 20P of the Minbu oilfield.

Rangoon Water Supply Hlawgaw Low Level Lake Scheme.

49. Mr. Leicester was deputed to examine a new reservoir site selected by the Rangoon Corporation for consideration among the numerous schemes already proposed for the extension of the existing inadequate supply of water to the City of Rangoon. The impounding area lies on the rice fields to the east of the low shelving ridge between miles 14 and 21 of the Rangoon to Prome road (17° 0′:

96° 40′) and it is proposed to construct a shallow reservoir 15 feet deep, with the 'take-off' about 9 feet below high water level, by means of low earthen bunds.

The geology of the area is simple and reveals the alluvium of the deltaic plain overlying the upper beds of the Irrawaddian series. The higher ground to the west of the rice fields would appear to consist of lateritised talus and sands and clays of the upper beds of the Irrawaddian series. Sandy clay-shale of the Irrawaddian series was met at a depth of 10¼ feet in a pit at the south-west corner of the area.

By far the greater part of the impounding area of the proposed reservoir rests upon the homogeneous clay of the Upper Delta Alluvium. This clay stretches up the gentle slopes of the ridge on the west to within a short distance of the proposed high water level, with the exception of the area known as the Grazing Ground which lies due east of the Mingaladon Wireless Station. This alluvial clay should form a practically impermeable and therefore ideal floor for a reservoir of this kind. Over the areas not covered by alluvial clay, a number of pits were sunk under Mr. Leicester's instructions, and from information gleaned from them, and the numerous village wells examined, it was found that in no place could the ground be considered to any appreciable extent porous.

Mr. Leicester indicated that at the points where the 'bunds' cross the streams, the silt bordering the streams should be removed and the core of the dam sunk well below the old stream bed, and that the arms of the bunds should be sunk well into the ridge and the impervious core well below any laterite met in it. The area outside the reservoir should be watched carefully in order to avert damage to the 'bunds' by meandering streams and flooding. A certain amount of river training may be necessary and, in exceptional circumstances, certain parts of the outside of the 'bunds' might have to be protected by pitching and rubble aprons.

Mr. Leicester's conclusion was that the area should be suitable for the construction of a water-tight reservoir bounded by earthen 'bunds'.

The Thitson Reservoir Project No. 1, Yamethin district.

50. The Irrigation Department proposed to construct an earthern dam across the Thitson River in Yamethin district, about one mile above the abandoned Hteinnyetkon Weir, and thereby form a reservoir with a full capacity of 13,000 acre-feet and an estimated

water spread of 1,250 acres. Geological advice was requested as to whether the area included within the proposed reservoir was suitable for this purpose, and whether the site chosen for the construction of an earthen dam, 1,800 feet long, with a freeboard of 3·62 feet above high water level and a maximum height of nearly 70 feet, was also suitable for its purpose.

Dr. J. Coggin Brown undertook this investigation. The site is reached from Yamethin by a road which leads in a north-north-westerly direction to the Thitson Chaung at Ywadan, $9\frac{1}{4}$ miles. From this place the bank of the Hteinnyetkon Canal is followed to the south-west as far as the weir of the same name at $12\frac{3}{4}$ miles. The dam site is about one mile further upstream.

The Thitson Chaung has a large catchment area and its feeders from the west and south-west drain back into the main range of the Yomas, which attains heights of 1,300-1,400 feet hereabouts and separates the Yamethin and Magwe districts. Like most of the streams in this part of Burma, the Thitson is dry for a considerable part of the year but is liable to sudden and severe spates in the rainy season.

The greater part of the catchment area lies on sheet 84 P/15, geologically surveyed by Messrs. C. T. Barber and B. B. Gupta in 1924-25, and is built up of rocks belonging to the Pegu series. In the east however these give place to Irrawaddians which stretch down the Thitson Valley, forming a band about three miles wide which rapidly increases to the south. Beyond the Irrawaddians lies the alluvium of the lower Thitson and Shweda valleys. The dam site and the eastern end of the impounding area lie on Irrawaddian rocks in sheet 93 D/3. The greater part of the proposed reservoir is situated on their extension to the west of this and only a small fraction of the total area that will be under water encroaches on the Pegu series. Mr. Gupta described the Pegu rocks generally as alternating beds of sandstones and shales varying greatly in texture and folded into a series of anticlines and synclines. The Irrawaddians were found to be soft, loose sandstones and gravels with red earth as a surface deposit in places where the topography was flat.

Dr. Coggin Brown's detailed examination shows that over much of the reservoir area and particularly in the lower portions near the banks of streams there is an irregular cover of sandy soil, but that in many places, especially on the high ground and in the actual bed

of the main stream the Irrawaddians crop out, generally as soft sandstones or sand rock, false-bedded, possessing little cohesion and badly consolidated. Such materials are porous, become quickly soaked with water, and, owing to their loose, friable character may then suffer disintegration.

The presence in one section of a system of veins of secondary calcium carbonate traversing the sand-rock to a depth of at least 30 feet is taken as clear evidence that, quite apart from the inherently pervious nature of the sand rock itself, water travels through the principal joint and bedding planes of this material, probably without the application of any marked hydrostatic head.

As the sandy soil, sand rock and soft sandstones described are permeable materials, it is, in Dr. Coggin Brown's opinion, a foregone conclusion that there would be leakage from a reservoir constructed on them. Whether such leakage would eventually be staunched by the deposition of clay in their voids owing to the circulation of muddy water is a question that could be decided only by the costly experiment of making the reservoir and awaiting results. In the recent deposits of the river bed, there is practically no mud nor clay to be seen, the finer material being perhaps carried out by the strong current of the spates and deposited on the plains, in which case the construction of the dam might induce its settlement in the reservoir itself. Taking all the facts into consideration, however, it was concluded that the reservoir site is not a good one.

Various pits had been sunk in connection with the dam and its attendant works and the results from these have been tabulated and studied in the full report. There is a monotonous uniformity in the results from all the pits, which revealed little but soil, subsoil and soft Irrawaddian sandstone in various stages of friability, materials that must be regarded on the whole as pervious, an opinion supported by laboratory tests on samples of the various materials.

Only in the borings in the river bed at the dam site were there any signs of a change to the good. In one hole at the centre line a band of hard, shaly clay, 11 inches thick, was found. A similar clayey layer, 1 foot thick, was met with, 11⅓ feet below the surface in a boring, 150 feet upstream from No. 1. In a similar position 150 feet downstream, at 6⅓ feet below the river bed, a thicker clay band is reported to occur. Intermediate borings however, at 100 feet in both directions, passed through the horizon of the clay into the usual soft Irrawaddian sandstones without encountering it.

There is thus some reason to suspect that the clay, or clayey layers, are merely lenticles of irregular shape lying amongst the permeable sandstones. Most geologists with experience of these Irrawaddian rocks would indeed be surprised if such was not the case.

As it is proposed to anchor the puddle trench of the dam in this clay band and at the same time to protect it by sheet piling, it is first of all essential, in Dr. Coggin Brown's opinion, to trench down to it along the whole length of the dam line in the river bed and then, by pitting or drilling, to prove whether there is a sufficient thickness for the purpose. Only in some such way can the dangers due to rapid lateral variation and irregularities of thickness, to which these deposits are prone, be guarded against.

In the absence of any such continuous impermeable layer, it is doubtful whether a watertight dam can be made in this situation. Percolation will then take place through the underlying sandstones, which might become rapid enough to result in their movement and the undermining of the structure. Another unfavourable feature, in this case a structural as distinct from a lithological one, is the change of the dip of the sandstones from their original W. N. W. direction upstream to the E. N. E. at 20°—25° near the proposed site. The dip is thus outwards from the reservoir and would augment the tendency towards leakage caused by the porosity of the beds themselves.

If it should be considered impracticable to continue with the existing Thitson project, and Dr. Coggin Brown was forced to the conclusion that both reservoir and dam sites are unsatisfactory, it was suggested that a suitable alternative site is more likely to be found within the area occupied by the Pegu rocks further upstream, which would not apparently decrease the catchment area a great deal. On the other hand, the economic practicability of such a site, presuming one exists, might be ruled out of consideration by the increased length of the canal system involved, an aspect of the question which is outside the province of a geological adviser.

51. A new site, just below the junction of the Thaikhmyaung *chaung* with the Thitson river, was chosen for the dam across the latter stream, as a result of Dr. Coggin Brown's report, though not exactly within the area suggested by him.

The Thitson River Reservoir Project No. 2.

The site selected lies 13¾ miles due west of Yamethin and nine miles S. S. W. of Yanaung in the Yanaung sub-division of the Yame-

this district: it is roughly four miles upstream along the bends of the Thitson river from the earlier site, the nearest village being Magyigon, not shown on the one inch sheet.

As the result of urgent representations in view of the proposal to construct the dam as a famine relief work, Mr. A. L. Coulson left Rangoon on the 16th September, 1931, to visit the new site.

The proposal was to form a reservoir of 11,000 to 14,000 acre-feet capacity, and water-spread of two square miles, by impounding the Thitson river with an earthen dam. The topography allowed of a dam less than half a mile long and of height 60 to 65 feet at the gorge crossing. The full tank level would be at R. L. 850 feet, the present bed of the Thitson being at R. L. 797 feet. This would give a maximum depth of water of 53 feet.

The catchment area of the Thitson above the proposed dam is about 108 square miles and, with the exception of a small area S. S. E. of Thaikhmyaung, another E. N. E. of Gwegon, and one north west of Aingdo, all of which are on Irrawaddians, is built of Pegu rocks surveyed in 1924-25 by Mr. B. B. Gupta. The Irrawaddians unconformably overlie the Pegus one mile S. S. E. of Thaikhmyaung.

Three dam lines had been tested in the vicinity of Magyigon village. The first of these, line B, had been rejected chiefly on account of the abundant presence of '*kyatti*' or alkaline earth, in the trial pits. The present proposed dam line, line C, was a modification of a former line, line A. Sixteen pits had been excavated along line A and its escape channels; four additional pits were sunk along lines A and C at Mr. Coulson's request. Additional information had been gained in certain pits and in the bed of the river by borings. All the samples had been tested chemically by means of phenolphthalein and by shaking with water to see whether or not the pernicious alkaline earth was present.

Mr. Coulson noted that all the dips of the rocks were approximately at right angles to the dam line C, which had a general N.-S. trend. The dips, however, were downstream and so did not tend to stability, though their amount as a rule was high. In the gorge section, dam line C made an angle of some 15° with the strike of the rocks, which dipped at 60°, to 10° S. of E. This angle is small but is unfavourable. Dam line A at the gorge crossing was distinctly bad, being almost at right angles to the strike of the rocks.

Mr. Coulson concluded, as a result of his observations, that with the succession of shales, shaley and micaceous sandstones, thin

sandstones, etc. proved by the trial pits to be discontinuous in nature, there was no strong, impermeable, continuous and easily recognizable bed, eminently suitable for anchoring the foundations of the proposed dam. The rocks on which it was proposed to build the dam were the higher members of the Pegus and were not dissimilar from the Irrawaddians. The boundary between the Pegus and the Irrawaddians lay just below the dam line.

Mr. Coulson concluded that sheet piling would have to be driven to a depth lower than R. L. 777·5 feet in the bed of the river; on the right bank, precautions would have to be taken to a level lower than R. L. 809·5 feet; and on the left bank, to a level lower than R. L. 789·0 feet, a considerable safety margin being allowed in all cases.

Abundant '*kyatti*' was proved in pits on the left flank of the dam line, the general thickness of the '*kyatti*' band being about 20 feet: the adequate protection of the proposed dam from this alkaline earth would undoubtedly prove expensive, though not too great as to render the use of a clay core impossible.

Mr. Coulson examined the escape lines and made detailed observations on the rocks in the Thitson river, upstream from the proposed dam, which would form part of the reservoir basin. Though better for the purposes of retention of water than the Irrawaddians, the Pegus form a far from ideal spread of rocks. At the time of Mr. Coulson's visit, the water in the Thitson carried a lot of silt and clayey matter in suspension, the greater part of which would be deposited in the reservoir when formed. The relatively porous basin would become gradually stanched by the deposition of this material, though it was probable such stanching would take a very considerable length of time.

There is a large variation of dip and strike in the strata a short distance upstream from the proposed dam site, the general direction of dip being, however, downstream. Further along the river, near Gwegon, the direction of dip is generally upstream. About three-quarters of a mile south-west of the village of Gwegon, a rather massive sandstone, about six feet thick, dips upstream at 35° to 50° N. of E. This sandstone would form a far more secure foundation for a dam than any other rocks noted between it and the present proposed site, but the conditions here are far from ideal. It is anticipated by Mr. Coulson that there would be considerable difficulty in proving this sandstone on the right bank of the Thitson

Upstream from it the dips and strikes alter largely but they are generally upstream, though local puckering and possible faulting were noticed.

Mr. Coulson concluded that the construction of the dam across the Thitson river at the site inspected by him could not be advised upon geological grounds. He suggested that the possibilities of the sandstone bed south-west of Gwegon should be examined and further exploratory work be undertaken upstream to the junction of the Thitson river with the Thitwinbin *chaung*.

The Daing Weir Project, Kyaukse district.

52. The Irrigation Department, Burma, proposed to construct a masonry weir in the Panlaung River about two miles above the existing Nathlwe Weir. It was to be about 180 feet long with its crest approximately 4 feet above the river bed and designed to allow a maximum depth of 23 feet to pass over its crest. Geological advice was requested as to whether the foundations were suitable for the proposed work and whether special precautions were necessary to ensure the safety of the structure. Dr. J. Coggin Brown undertook this duty.

The site lies on sheet 93 C/7, about 5 miles south-east of Ywakainggyi, a village 10 miles to the south east of Myittha railway station in the Kyaukse district.

This site is about half a mile downstream from the Ingon dam site on which Dr. G. de P. Cotter reported in 1923.[1] The Ingon dam site crossed andesite, alluvium and 'concrete,' which was defined as travertine frequently containing limestone pebbles. Dr. Cotter regarded the andesite as a safe foundation, but advised careful investigation of holes which appeared in the 'concrete.' According to Mr. C. T. Barber, who investigated the Nyaunggyat Dam Project[2] still further up the Panlaung Valley in 1924, the work that Dr. Cotter advised revealed that the 'concrete,' hard and compact at the surface, became soft and friable in depth, and this led to the abandonment of the Ingon site.

The dominating topographical and geological features of this part of the Panlaung Valley are the two hills, Kandaung on the east, the 1,380 ridge of the one-inch map, an outlier of the main limestone mass behind, and Mondaung, 1,696 feet, on the west. The latter runs approximately north and south for some four miles from a point one mile south of Ywakainggyi to the latitude of Ingon and

[1] *Rec. Geol. Surv. Ind.*, LVI, p. 26, (1924).
[2] *Op. cit.*, LVIII, p. 26, (1925).

controls the course of the river hereabouts. The western half of Mondaung is composed of limestone and the eastern half, flanking the river, of andesites and porphyrites.

A spur runs off from the main Mondaung mass towards the east and forms Tauktet Taung, point 745 of the one-inch map. This spur is important. The Ingon dam was to block the shortest and steepest part of the valley between Tauktet Taung and Kandaw hill, but the Daing weir site lies in a more open part of the valley and, while still close to the north-eastern flank of Tauktet Taung, is three quarters of a mile from the steep limestone slopes of Kandaw. It is this greater distance from the limestone that accounts for the absence of travertine and other objectionable sub-surface deposits at the Daing site.

Dr. Cotter described two varieties of andesite from Tauktet Taung, one a speckled rock with phenocrysts of altered plagioclase and smaller crystals of augite and plagioclase, and the other a uniformly dark grey rock with a similar composition and structure.

At the weir site on the east bank, the rocks are buried under the alluvium. On the opposite bank are exposures of fresh, silicified andesites, very hard, tough and compact rocks belonging to Dr. Cotter's dark grey variety. A number of borings were being made across the river at intervals of 50 feet. Small pieces of bedrock from borings Nos. 1, 3 and 7 were all representatives of the same type of hard silicified igneous rock. As identical rocks occur in borings of both banks of the river and in at least one hole in the river bed, it is reasonable to suppose that at this particular line, the andesites stretch right across.

Dr. Coggin Brown expressed the opinion that these rocks will form a safe foundation for the weir, provided it is taken down into firm, fresh rock, and advised that in opening up the site particular attention should be paid to the occurrence of joints and fissures which if present and open should be cleaned out and grouted.

Uhl River Hydro-Electric Scheme, Mandi State.

53. Reports on the Uhl River or Shanan Hydro-Electric Scheme have already been made by Mr. Crookshank,[1] Dr. Fox[2] and Mr. Gee,[3] of this Department. On account of the recent occurrence of landslips near the pipe line and haulage way, Mr. Auden was deputed, to-

[1] *Rec. Geol. Surv. Ind.*, LVI, p. 27, (1924).
[2] *Ibid*, p. 28.
[3] *Op. cit.*, LX, p. 38, (1927); LXV, p. 44, (1931).

gether with Mr. Cargill, Superintending Engineer, P. W. D., to make an examination of the hill side. They visited Jogindernagar during the first week of May 1931. Mr. Auden's report refers more particularly to the geological nature of the hill side, while Mr. Cargill details some protective measures to be adopted.

A report had been previously prepared by Col. Battye in February 1931, and outlined the sequence of events since 1928, when the trouble first began. There are two *nalas* east of the haulage way, which run south to join the Neri Nala just below the road between Wyer bridge and Shanan. These have been termed respectively eastwards: Nalas A and B. During the heavy monsoon of 1928, Nala A began to scour its bed to a depth of from 15 to 20 feet below its usual level. The drainage of the upper part of Nala A was then diverted into Nala B, since when scouring in Nala A appears almost to have ceased, but has become considerably aggravated in Nala B. Subsequently slips have occurred continuously in the ground west of and adjacent to Nala A, between it and the haulage way. One area, of from two to three acres, has sunk 35 feet, along peripheral fissures which open out into the eroded right bank of Nala A. Further up, towards the haulage way, are lesser slips, safety of the and scree ground. Fears were consequently entertained for the pipe line and haulage way. In addition, there are slips above the adit tramway, occasioned by two small *nalas* which have increased in size as a consequence of quarrying and other operations. Col. Battye suggested various protective measures, which include the erection of crate bunds throughout the length on Nala A, the fencing in and afforestation of the affected area, and the construction of drains.

Mr. Auden states that the general condition of the hill side is bad. Below the adit tramway, the dip of the schistose and phyllitic rocks is southerly, parallel to the surface of the hill. Both these rocks and the overlying quartzites of the surge shaft, are strongly sheared and jointed, readily breaking up into irregular splinters and fragments. The chloritic and micaceous minerals of the schists and phyllites, on disintegration, produce a soft clay-like matrix in which are embedded boulders and fragments of rock not yet broken down. There results a 'boulder clay,' which, when saturated with water, is very liable to slip. The greater part of the hill side is made up of a thick mantle of this deposit, which obscures the rock *in situ* beneath. It is well over 50 feet thick in places, but probably de-

creases in thickness towards the haulage way. The haulage way rests on a slight ridge. Rock is not found *in situ* in the cuttings along this way, until up near anchor No. 3. The screes, which lie just to the south-east of this anchor, have probably descended only a short way from their original rock outcrop. The existence of a ridge would certainly suggest the proximity of rock *in situ* just below the haulage way, and not an excessive thickness of 'boulder clay'.

Every factor of dip, jointing and mineral content predisposes this hill side to slip. However, since Nala A and the haulage way diverge more and more as the hill is descended, it is unlikely that slips low down in Nala A would seriously affect the stability of the haulage way. The possibility of stability being endangered is higher up, in between the sunken 'field' and the screes, but this is to some extent lessened by the almost certain decrease in thickness of the superficial deposits towards the haulage way.

With regard to the causes of these slips, Mr. Auden states that the potential cause of unfavourable rock disposition is beyond control, but suggests that under normal conditions adjustment of the 'boulder clay' to its solid rock foundation may lead to equilibrium and relative permanency in position of the 'boulder clay'. The minor causes affecting this equilibrium are those of river erosion and saturation of the clay matrix to the 'boulder clay' with water. Erosion has been intensified by the dumping of debris from quarrying operations and excavation works for the adit tramway, into Nala B, and by the heavy monsoon of 1928, which must have exposed a boulder-rich clay high up in Nala A and have caused aggravated erosion lower down. Protective measures to combat these latter causes have already largely been adopted. Additional measures, or modifications, have been put forward in the reports of Messrs. Auden and Cargill :—

(1) The debris from the quarries above the adit tramway should as far as possible be dumped away from Nalas A and B, or, if possible, the quarrying operations should be closed down and moved to another part of the outcrop of the quartzites.

(2) Besides the building of crate bunds, which will act as lateral support to the 'boulder clay' recently bereft of its support by erosion, and which will check the velocity of the water in spate, Mr. Cargill proposes the revetting of the banks

of the *nala* with boulder crates, thus preventing direct contact of spate waters with the foot of the slips. Mr. Cargill points out that the bund fillings should not be grouted, nor the downstream faces of the bunds protected with cement concrete. Water coming down the *nala* should be allowed to find its way both over and through the bunds.

(3) The construction of drains. Mr. Cargill remarks that these should be placed above the areas of subsidence, and not across them, and that they should debouch into Nala A in places where the bank is either low or stable.

Gold.

Myitkyina district, Burma.

54. A gold-bearing locality in the crystalline schists, which is locally known as Jamaw (25° 25′ : 96° 18′), occurs, according to Dr. H. L. Chhibber, near Woragahtawng (25° 25′ : 96° 17′). Numerous old pits with a general depth of 10 to 12 feet were seen in this neighbourhood. The locality is said to have been abandoned about 14 years ago.

Dr. Chhibber was informed that the Kachins of Jaiwa Ga (25° 28′ : 96° 53′), Hpawchyun (25° 56′ 30″ : 96° 52′) (now deserted) and Hkakugatawng (25° 57′ : 96° 42′) used to wash for gold in the Shadu Hka, but the locality was deserted long ago.

The sands of the Namsang Hka are reported to be rich in gold and in the past there used to be considerable activity in certain places. To-day the villagers of Laban (25° 52′ : 96° 40′) and Wakawng (25° 50′ : 96° 39′) practise gold washing on a small scale.

Kashmir.

55. Mr. Wadia inspected some of the gold washing sites on the bed of the Indus in Gilgit and Chilas. The fairly extensive stretches of sand that occur along the bank, and in the high and wide talus-fans and gravel-terraces skirting the bed of the river, have been known to be auriferous from ancient times. The extraction of gold forms a subsidiary industry, fitfully pursued by the scanty population of this desert land, chiefly by a small community of gold washers (*sunniaras*) living in hamlets along the river. The Kashmir Government issues licenses for gold washing at from Rs. 8 to Rs. 10 per annum. The gold occurs as visible dust and pellets and rarely as small nuggets, in a deep black

sand containing predominant magnetite with garnets, epidote, zircon and other heavy minerals. Generally a whole family of *sunniaras* engages in washing for a season, the day's wage varying from twelve annas to as much as three or four rupees. The *sunniaras* exhibit great dexterity in handling the pan (a wooden boat-shaped dish, about 2½ feet long, called the *kishti*) much of the success of a family being due to the manipulative skill of a single operator.

Although alluvial gold is known to be widely distributed in the Gilgit district in the gravel-fans, terraces and sand-banks of the Indus, yet it is not known whether the auriferous content is sufficient to support a modern organised industry. No gold-bearing lodes have yet been located.

Prospecting for other precious metals, particularly those of the platinum group, offers some chance of success in parts of the district where the sands derived from the weathering of the serpentinised ultra-basic segregations have been concentrated at favourable sites; such localities may occur around Godai (35° 8′ : 75° 0′), Kalapani (34° 40′ : 74° 53′), Babusar (35° 9′ : 74° 2′), and Pashwari (34° 46′ : 75° 1′).

Graphite.

Myitkyina district, Burma.

56. Graphite-schists with a high content of the mineral occur, according to Dr. H. L. Chhibber, at the following places in the Myitkyina district:—near Lawa Htengsa (25° 33′ : 96° 49′); Tatbum (25° 36′ : 96° 50′); a little east of Mupaw (25° 52′ : 96° 53′) and between 'Nhpum (25° 45′ : 96° 51′) and Warawng (25° 41′ : 96° 50′). The 3,068 hill between Kauri (25° 45′ : 96° 51′) and Auche (25° 43′ : 96° 50′) is built of similar rocks, but it is doubtful if the mineral occurs in commercial quantities there.

Iron-ore.[1]

Myitkyina district, Burma.

57. A number of irregular blocks of schistose and massive haematite, ranging up two feet or more in diameter, were found by Dr. H. L. Chhibber, not *in situ*, associated with boulders of porphyritic gneiss about one furlong north-east of the Ngawmawalang Hka bridge on the Myitkyina-Htawgaw road.

[1] These occurrences were actually noted during field season 1929-30, but were not reported in time for inclusion in the last General Report.

Segregations of magnetite occur in the margin of a granite batholith about a mile north-west of the Lagwi Pass (25° 50′ : 98° 30′).

Jadeite.

58. During the course of his work in the Kamaing sub-division Dr. Chhibber paid a short visit to the jadeite mines to study the condition of the mining industry.

Myitkyina district, Burma.

At Tawmaw (25° 41′: 96° 15′) both the Kadon dwin and the Dwingyi were being worked. Dewatering of the Kadon dwin commenced about the middle of December, 1930, and the mine was dry by the 24th of January, 1931. Actual drilling commenced two days later and two pneumatic and two hand drills were operated. Mining was concentrated in the E. S. E. face, measuring 32 feet across in the footwall. In the greyish coloured *palun* (albite) two lenses of jadeite were being followed; one occurred on the E. N. E. and the other on the southern corner of the working face. The general direction of dip was south-east and the *palun* in between was highly jointed, dipping S. S. W., at 60°. One of the lenses was three feet thick with a thin layer of *shin* (amphibolite) at the top and bottom.

It was observed that the *aye* or green variety, the most valuable form of the mineral, is associated with small inclusions or irregular lenticles of *shin* (amphibolite or amphibole-schist) and tawmawite (chrome-epidote) and Dr. Chhibber thinks that the green colour has developed as a result of the absorption of colouring matter from them.

Dr. Chhibber made a rough survey of the Dwingyi and found that nine claims were being operated. The owners were Chinese with the exception of one Burman and one Kachin.

The most remarkable event of the year in the jadeite industry was the working of the occurrence locally known as *Mawthit,* about 1¼ miles E. N. E. of Tawmaw (25° 41′ : 96° 15′) and about half a mile from the Lonkin-Tawmaw road. This was the biggest mining camp during the season and, as a result, activities at Hwehka (25° 29′ : 96° 17′) and other places received a set-back.

The enterprise failed, however, because what the miners thought was a detrital deposit suitable for working by shallow pits was in reality a large jadeite outcrop *in situ.*

Among the Uru boulder conglomerate workings, Hpakangyi (25° 36′ : 96° 18′) was the biggest centre of activity, as six valuable stones were won during the year. It was noticed here and elsewhere that the miners were redigging the old pits and going deeper, as almost the whole of the ground occupied by the jadeite-bearing conglomerate has been dug over and consequently the jadeite boulders are getting scarcer. The future of the industry now lies in the outcrop mines at Tawmaw and elsewhere.

Kaolin.

Garo Hills, Assam.

59. While examining the coalfields of Rongrenggiri and other in the Simsang Valley of the Garo Hills in January and February, 1931, Dr. Fox found that the most characteristic strata of the Upper Cretaceous outliers, in which the coal seams occur, are white sandstones and kaolin. The most northerly and therefore least attractive of these occurrences lies near Agalgiri, $1\frac{1}{2}$ miles east of Songsak (25° 38′ : 90° 37′). The most evident exposure is that in the Simsang river and around the inspection bungalow of Rongrenggiri (25° 33′ : 90° 33′). This kaolin is seldom absent from the Upper Cretaceous strata in the exposures below Siju (25° 22′ : 90° 41′), and the hills east of Rewak (25° 19′ : 90° 40′). The specimens brought by Dr. Fox from Rongrenggiri are white and suitable for the purposes of china clay. The clay is sufficiently low in iron oxide to remain white after firing and consequently falls in the category of fireclay. The private explorations carried out in the Asilgaon Hill coalfield have shown that a bed of fireclay of good quality is found below the coal.

Lead-ore.

Pindaya State, Southern Shan States.

60. Galena occurs, according to Mr. V. P. Sondhi, in stringers and thin veins in the argillaceous limestone forming the steep hill one mile to the south-east of Alechaung (21° 0′ : 96° 33′). A few old prospecting pits exist in the vicinity and pieces of slag were found in the stream bed below the hill.

Myitkyina district, Burma.

61. Dr. H. L. Chhibber reported the discovery of old Chinese workings for lead-ore in limestone near the village of Wanghte (25° 50′ : 98° 8′). He does not think the locality possesses any commercial importance.

Nandgaon State, Central Provinces.

62. Six hundred yards west of the village of Muhripar (21° 21′ : 80° 52′ 30″), quartz-veins containing ores of lead and copper occur in a narrow band of steeply dipping slate and 'greenstone' that emerges from an alluvial plain. The total outcrop is about 50 yards long by 8 yards wide, and strikes N. - S. The main ore-bearing quartz-vein varies from one to five feet in thickness, and runs N. S. through the centre of the exposure, whilst smaller ore-bearing veins string out into the country-rock.

The ores present consist of galena, occasionally enclosed in cerussite and anglesite, with subordinate quantities of chalcopyrite, malachite, azurite, and covellite. An assay of a sample of galena, carried out by Mr. J. R. Hutchinson of Calcutta on behalf of the State, showed 57·88 per cent. of lead and 3·02 ozs. of silver to the ton. This must, however, have been a selected sample, for Dr. S. K. Chatterjee, who visited this locality in compliance with a request from the State, calculated that even in the richest part of the lode the percentage of galena does not exceed 1·15.

The long-known lead locality of Chandi Dongri (20° 4½′ : 80° 37½′) on the Great Eastern Road, about a mile west of Ranitalao (some three miles west of Chichola) lies partly in Khairagarh (northern portion) and partly in Nandgaon State, Central Provinces. A short note on this occurrence by W. T. Blanford is included in the *Records, Geol. Surv. Ind.*, III, page 45, (1870). According to Dr. Chatterjee, who visited this deposit at the request of the Nandgaon State, the ore (galena) occurs in well-marked veins, chiefly composed of quartz and fluorite, which strike north-south in a country rock of grey coarsely porphyritic biotite-granite. The whole hill probably represents a fault-zone. The original fault-fissures appear to have been filled with pegmatite. During later movements, the pegmatite was brecciated and partly replaced by the ore-bearing quartz-flourite vein, whilst still later barren quartz-veins cut across the former.

The portion of the hill lying in the Nandgaon State is about 500 yards long, 40 feet high, and from 30 to 80 feet wide. The flourite-quartz veins are more or less vertical, and occupy the greater part of the outcrop.

In 1914 a mining lease for the extraction of lead-ore was granted over the area to Mr. T. B. Kantharia of Bombay. Six pits were sunk, and 'the stone excavated was said to contain a very small

amount of lead.' The percentage of lead-ore in the lode is considerably less than that at Muhripar, and the occurrence is consequently of no economic use from the point of view of that mineral. The deposit may, however, be of economic value as a flux in open-hearth steel furnaces for its flourite content, though this is rather doubtful owing to the difficulty of separating the flourite from the quartz.

63. Specimens of galena with quartz were sent to Dr. Cotter by the Chief Magistrate to the Nawab of Amb. These are said to come from a locality called Charyali, three miles west of Khaki, Hazara district, (34° 24′ : 73° 7′).

Hazara district, N. W. F. Province.

Marble.

64. Dr. A. M. Heron made a detailed examination of the celebrated marble quarries at Makrana, to advise the Jodhpur Durbar whether any improved methods of working could be introduced, or assistance given to the industry.

Makrana, Jodhpur State, Rajputana.

It is probably impossible to establish any improvements in the actual methods of quarrying, because of the multiplicity of quarry lessees, their poverty and their stubborn conservatism, but Dr. Heron has suggested means by which transport might be facilitated. It must be remembered that the quarries have been badly worked for over 300 years, and little can now be done to remedy the chaos that has resulted.

A branch railway, with sidings, runs along the western side of the ridge in which the quarries are situated over a length of five miles. Access to the sidings is impeded by the accumulation of waste from the quarries, and this should be cleared away where necessary. Along the other side of the quarries a metalled road should be made into the town of Makrana, where most of the stone is worked up. Dr. Heron suggests the provision of sets of simple winches and hauling tackle, either on hire or for sale on the instalment plan, to improve the painfully laborious and inefficient ways in which the blocks are raised from the deep quarries. As to the future, the steep dip of 60 degrees renders an expansion of quarrying prohibitively costly in the direction of the dip, but prospecting might be tried along the strike of the worked sections in the covered spaces between them, where the crest of the rocky ridge falls below the surface of the sandy plain.

65. White marble of dolomitic composition, and identical with that at Rajnagar, is reported by Mr. B. C. Gupta to be quarried for local building purposes at Lawa (25° 14′ : 74° 6′) and Kosithal (25° 19′ : 74° 13′); it is much used in the vicinity.

Udaipur State (Mewar), Rajputana.

Mica.

66. Dr. S. K. Chatterjee reports the occurrence of mica in a small pegmatite vein about 20 yards long by 2½ yards wide and striking north and south through fine-grained biotite-gneiss in the bed of a stream at Tilairwar (21° 2′ : 80° 47′), Nandgaon State. The mica (muscovite) is white and unspotted, but the maximum size of the mica books does not exceed 1½ square inches. The occurrence is of no economic value.

Nandgaon State, Central Provinces.

67. Dr. Heron reports that the pegmatite dykes of northern Mewar often contain marketable muscovite in considerable amount. This mica is stainless and obtainable in pieces up to seven or eight inches square. Superficial diggings were tried with fair success during the Great War.

Udaipur State (Mewar), Rajputana.

Natural Gas.

68. The Executive Engineer, Dacca Division, Eastern Bengal, informed this department that a tube-well under construction had struck gas in a small village named Saharmul (Karpassa) in the Kishorganj sub-division of the Mymensingh district. This was the first occurrence of natural gas reported from Eastern Bengal. Mr. A. M. N. Ghosh was deputed to the locality in order to investigate the cause of the outburst. As the emission of gas had completely ceased before Mr. Ghosh visited the locality, he collected information about the occurrence from several people who happened to have been there. It appears that a tube-well boring after passing through a layer, 15 feet thick, of carbonaceous clay containing remains of semi-decomposed carbonised woody materials found at a depth of about 170 feet, stuck at 210 feet below the surface. In the course of lifting it out, the casing was kept at a level of 175 feet from the surface inside the carbonaceous clay bed. On the 11th March, 1931, at

Mymensingh district, Bengal.

midnight, an underground rumbling was heard and a gas which proved to be inflammable issued from the pipe. The first outburst of gas was followed by a continuous discharge of a mixture of gas, water, mud, and silt. This phenomenon lasted for 7 days and varied in intensity and violence. On the last two days black carbonaceous mud was ejected alternately with gas. The violence of the outburst diminished after the first few days and later on, when the casing was taken out, it subsided gradually. As the outburst of gas took place while the casing was inside the carbonaceous clay bed containing remains of decomposed vegetable matter, it is suggested that the boring struck a local zone of pressure resulting from an accumulation of marsh gas. Methane or marsh gas is known to be formed in swampy places from decaying vegetation.

Mr. Ghosh also collected some gas that was bubbling through the water in a neighbouring tank, and two bottles of gas samples were sent to Prof. C. Forrester of the Indian School of Mines, Dhanbad, for his opinion. The average result of three analyses is given below :—

	Per cent.
Methane and other saturated hydrocarbons	81
Unsaturated hydrocarbons	*nil*
Carbon monoxide	*nil*
Carbon dioxide	4·6
Hydrogen	2·8
Nitrogen (by difference)	10·4
Oxygen	1·2
Total	100·00

69. Reports of a somewhat similar occurrence come from Burma where a boring for water at a rice mill at Thetakla, Kawa township, Pegu district (17° 2′ : 96° 36′) encountered inflammable gas which was used for lighting and cooking purposes on a small scale. This gave rise to rumours of the occurrence of petroleum under the south Pegu plain and Mr. L. R. Sharma, Chemical Assistant to the Burma Party, was deputed to investigate the question. He reported that the gas was marsh gas (methane) from a layer of coarse-grained sand, 5 feet thick, 160 feet below the surface. The gas sand was sealed above by a thick layer of bluish, sandy clay, but the diminution of the pressure and volume of the gas within a few months showed that the supply was limited and the sand of no great lateral extent.

Pegu district, Burma.

Chemical tests prove the absence of heavy hydrocarbons, and the presence of decayed vegetable matter in the boring samples shows that the gas is not associated with petroleum but was probably formed by the slow decomposition of vegetable matter in these deltaic deposits.

Natural gas resources of Burma.

70. It has become a matter of importance to collect and summarise our information upon the natural gas resources of Burma. This work has been entrusted to Mr. C. T. Barber, Resident Government Geologist at Yenangyaung, the co-operation of the oil-producing companies has been secured and it is hoped that the investigation will be completed during the current year.

Helium in natural gas.

71. At the request of the Director of Civil Aviation, arrangements have also been made for the collection of samples of natural gas for the determination of their helium contents. The Indian Institute of Science, Bangalore, has undertaken the analysis of the samples.

Petroleum.

Resident Geologist, Yenangyaung Oilfield.

72. Mr. C. T. Barber held charge of the office of Resident Geologist, Yenangyaung Oilfield, throughout the year. Amongst the subjects upon which he gave advice was the proposed amendment of the Burma Oil Fields Act, 1918, in which, it has been felt for some time, insufficient prominence is given to the conservation of oil and gas. In order to bring the Act into line with modern practice in the conservation of oil and gas, it is necessary to redraft nearly all the clauses dealing with the control of drilling and producing operations. Proposals for redrafting these clauses were made by the Warden of the Oil Fields in consultation with the Resident Geologist and the proposed draft has also been the subject of comment by Dr. Coggin Brown.

Amendment of the Burma Oil Fields Act, 1918.

Precautions for drilling through deep or unknown horizons.

Recommendations have been made by the Resident Geologist for the prohibition of the penetration of deep or unknown horizons by wells on which high pressure fittings have not been installed. The installation of high pressure fittings is necessary both for the protection of productive sands from water under high pressure during

the drilling of wells, and also for the control of oil and gas under high pressures.

73. During the year Mr. C. T. Barber visited the Indaw oilfield in the Upper Chindwin district, Burma. He was allowed to study the large-scale geological map prepared by the geologists of the Indo-Burma Petroleum Company and the production and drilling records of the Company. The following summary of his report is published with the concurrence of Messrs. Steel Brothers, the Managing Agents to the Company.

Indaw Oilfield, Upper Chindwin district, Burma.

This field is situated on an inlier of Pegu rocks some 18 square miles in area. Structurally it is an elongated dome, the axis of which is oriented in a N.N.E.-S.S.W. direction. The structure is distinctly asymmetric, dips on the east flank rising to 65°, while those recorded on the west flank rarely exceed 20°.

The exposed members of the Pegu series present a dominantly sandy facies, and the highest members consist of soft buff sandstones, differing in lithology from the overlying Irrawaddian sandstones mainly in the rarity of small quartz pebbles, which are abundant in the lower members of the Irrawaddian series. In the lower exposed members of the Pegu series thin beds of clay and shale make their appearance, and are still more prevalent in the strata which have been penetrated by the drill, but remain, in the horizons yet penetrated, subordinate to the sandstone members of the series.

In an area of approximately a quarter of a square mile, centrally situated on the Pegu inlier, oil sands occur between the depths of 800 and 1,200 feet, and it is from this zone that the bulk of the present oil production of the field is produced. Water sands occur above the main oil zone at depths varying from 50 to 600 feet, but they are under a low head and water is not a serious problem as far as this zone is concerned.

No oil sands of proved value have yet been encountered below this zone, but in Well No. 44 oil sands that may possibly prove productive were encountered at depths of 1,964 to 1,979 feet and 1,990 to 2,005 feet.

All the test wells drilled to any considerable depth below the main oil zone have encountered gas under high pressure in sands ranging in depth from 1,300 to 2,900 feet, and most of them have also encountered water sands under high pressures.

No oil sands of proved commercial value have yet been discovered outside the small proved area, situated in the centre of the inlier, but high pressure gas sands have been recorded in the logs of two wells situated on adjacent portions of the structure.

This field has been developed in the face of difficulties of transport and climate unparalleled in any other developed field in Burma. Since their entry into the field in 1912 the Indo-Burma Petroleum Company have drilled 41 wells to the productive zone in the proved area, and the limits of production have locally been proved on the east and west. In addition, 4 test wells have been drilled below the productive zone in the proved area. Of these Nos. 1, 11 and 22 were discontinued at depths of 1,808, 2,539 and 2,754 feet respectively on account of high gas pressure. No. 44 is still in progress at a depth of 2,953 feet. Six test wells have also been drilled on other portions of the structure to depths varying from 219 to 1,842 feet. None of these outside test wells having yielded oil on a commercial scale, the Company have concentrated their recent testing operations in the area already proved to contain the main oil zone, which in the opinion of their geologists offers the best prospect of production from greater depths. It is improbable, however, that in the event of these tests proving abortive the Company will withdraw from the field until they have thoroughly tested other portions of the structure. It may be assumed with equal confidence also, that the discovery of a good deep sand in the proved area would be followed by exploration for it in other portions of the structure.

Commercial quantities of oil were first obtained from Indaw in 1918 and since that time the production has risen, with minor fluctuations, to a peak of 70,540 barrels in 1929. Failing some new source of production, it can be maintained at this level only by the drilling of some six or seven productive wells per annum. In view of the difficult nature of the topography, and the limits of production having been reached on the east and west of the productive area, the location of these wells is becoming a matter of increasing difficulty, and Mr. Barber shares with the advisers of the Company the view that the future prospects of the field are bound up in the possible existence of prolific sands in horizons not yet penetrated.

The natural gas resources of the area are very great and at the present time there is an available production of some 12 million cu. ft. per day. Furthermore, in view of the very slight decline in yield and in working pressure of Well No. 1 during the past 15 years, if

may be concluded that the reservoir from which this well is drawing its supplies of gas is of very great extent, and, apart from the possibilities of mechanical trouble in the well itself, it may be confidently anticipated that it will continue for many years to yield a production not greatly inferior in volume to its present production.

It is not possible at the present time to make any accurate volumetric estimate of the potential production of gas from sands which have been encountered in test wells and which are now sealed off, but in view of their great lateral extent, and the high pressures which exist in them, there can be no doubt that their potential production greatly exceeds the present available production of some 12 million cu. ft. per day.

Yenan, Upper Chindwin district, Burma.

74. On the occasion of his visit to Indaw, Mr. Barber also inspected the test well of the Burmah Oil Co., Ltd., at Yenan (23° 56′ : 94° 30′). This well is situated slightly to the west of the culmination of the dome of an asymmetric anticline, on the east flank of which dips vary from 20° to 45°, and on the west flank from 10° to 20°.

Gas seepages are conspicuous in the Yu River where it crosses the crestal portion of the anticline, and 450 feet south-east of the well a small mud vent is active. Another small mud vent is situated south of the Yu River, some 1,450 feet south of the well. Apart from the gas seepages, the phenomenon which impressed Mr. Barber most was the intensive shattering to be seen in the sandstone beds exposed in the southern portions of the Yenan Chaung and in the thin seams of low grade coal that outcrop there.

Progress in the test well was slow owing to gas pressure and heaving formations, and in January 1931 the well had reached a depth of 976 feet.

Salt.

Myitkyina district, Burma.

75. Several brine springs were noted by Dr. H. L. Chhibber during the course of his survey of the Kamaing sub-division of the Myitkyina district. They are noted below :—

Tagum Jum (25° 27′ : 96° 50′).
Shadu Jum (25° 57′ 30″ : 96° 50′).
Pilan Jum (25° 45′ 30″ : 96° 48′ 30″).
On the Pidaung Hka (25° 25′ : 96° 17′).
On the Sahmaw Kka (25° 16′ : 96° 45′).

Salt is frequently manufactured by the local Kachins at these localities.

Brine springs were found by Dr. H. L. Chhibber at the following additional places in another part of the same district:—

(1) About 100 yards S.S.E. of the point where the path to Wuman leaves the Seniku Road (25° 26′ : 97° 42′).

(2) On the Htawgaw road 57 paces to the south-east at a point 330 paces short of mile post 31 (25° 46′ : 98° 1′).

(3) A short way to the south-east of (2).

(4) Near the third bridge in the 20th mile of the Seniku Road.

Sulphur.

76. Mr. H. M. Lahiri reports that springs charged with sulphuretted hydrogen were noticed near the boundary of the nummulitic (Laki) limestone with the Kamlial-Murree sandstones to the south of Kund Suleman (32° 38′ : 72° 1′) in sheet 43 D/2.

Shahpur district, Punjab.

Water (see also Engineering questions).

77. Mr. Leicester completed his investigations of the sources of underground water at Bassein, mentioned in the last General Report.

Bassein, Burma.

After collecting data about the existing tube-wells and tabulating numerous analyses of the water obtained from these wells, he was able to prove the existence of two gravel beds in the Lower Delta Alluvium dipping towards the river. The upper gravel is, on the whole, not so coarse under the higher ground as the lower gravel, which has a thickness there of about five feet. The top of this bed is at a reduced level of—117 feet (G. T. S. datum) at Myetto, and —119 at Kanthonzin, whence it dips towards the river until it is at R. L.—146 at the Victoria Gardens tube well near the river bank. The lower gravel bed appears to be coarser, thicker, and rather less regular than the upper gravel bed and the top of the former is at a reduced level of—212 at Myetto, about —245 at Kanthonzin, and round about —250 to —300 near the river.

A study of the analyses shows that wells sunk into the lower gravel yield brackish water (36 to 68 parts of chlorine per 100,000) with high total solids, while wells sunk into the upper gravel, and situated not far from the river, yield fresh water (2 to 11 parts of chlorine per 100,000) and low total solids.

A test conducted during the night of May 10th-11th, 1930, on the Victoria Gardens tube well, which is situated some 200 feet from the river bank, showed a 3-foot variation in static water level with a 6-foot tide, and this establishes the connection between the river and the upper gravel.

In Mr. Leicester's opinion the brackish water represents a vast store of occluded sea water lying beneath the delta. Further pumping might draw in more brackish water, as the superficial covering of impermeable Upper Alluvium prevents any large quantity of rain water from percolating downwards and diluting the salt. On the other hand, the more superficial fresh water of the zone bordering the river must be derived from the river itself, the water of which has been shown to contain less than one part per 100,000 of chlorine and remarkably low total solids.

Of numerous schemes which have been suggested for the improvement of the water supply of Bassein, Mr. Leicester has pointed out that the one which advocates the drilling of tube wells, located near the river bank, into the upper gravel bed would require very little further investigation. It would be necessary to select a place where this bed was known to exist and the connection with the river had been proved by tidal variation of water level in a test well. Though with increased pumping, the water might become slightly more brackish, it is extremely improbable that the water would ever become as salt as that at present obtained from the Kanthonzin wells. Surface contamination could be overcome by avoiding the unsavoury bazaar area of the town, but bacteriological contamination due to the river water, which might not be sufficiently filtered in its journey through the porous sands and gravels, might have to be dealt with by chlorination or some such method.

Another scheme, that of deep surface wells and galleries along the river bank, would need further careful investigation. A site would have to be chosen where the river banks were known to be porous and tests of tidal variation of water level would have to be carried out. This scheme has the advantage, however, of freedom from possible contamination of the water by the deep-seated and inland saline waters.

Rangoon.

78. Mr. Leicester completed his investigations into the geology and underground water supply of Rangoon and has submitted a report dealing with these questions. After describing the geology of Rangoon and sur-

rounding country in detail and outlining the geological history of the area, a tentative correlation of the Pleistocene deposits of Rangoon with those in Upper Burma recently studied by Mr. T. O. Morris of the Indo-Burma Petroleum Co., and changes of sea-level brought to light by recent oceanographic research in the Indian Ocean, is made.

The remainder of the report deals with the underground water of Rangoon, with special reference to the numerous tube wells which have been sunk in and around the city. Mr. Leicester has divided Rangoon into a number of easily defined blocks and discusses the conditions pertaining in each block, the different horizons from which water is obtainable, and the barren, brackish or unprofitable areas. It has been shown that on the west of the Rangoon ridge the origin of the underground water is not from the north by underflow parallel to the river but from the porous catchment area of Lower Delta Alluvium flanking the main ridge of Irrawaddian rocks. The question of the ingress of brackish water has been studied, and, after estimating the volume of the original store of fresh water in the porous beds, the probable annual contribution of fresh water is balanced against the estimated quantity of water extracted. Though there would appear to be a slight balance in favour of the fresh water, in the absence of any appreciable underflow from the north, the irregular distribution of the wells and the large quantities of water extracted within limited areas will probably result in certain areas becoming brackish. This would occur where the river water and the deep-seated saline water of the delta have easy access to the water-bearing sands and gravels.

Mr. Leicester recommends that no further wells should be sunk in certain blocks bordering the river in the south, where great quantities of water are being extracted and the salt water is advancing inland. He also recommends pumping at the time of low tides and restriction of pumping at high tides in these blocks and suggests two periods of six hours in 24 hours. Any great increase in the extraction of water to the east of the area bordering the river bank in the south would harm existing wells in certain blocks. On the other hand there is room for a limited increased extroction of water to the north.

Besides Rangoon the cases of Syriam, Insein, Thingangyun, Panhline, Seikgyi, Dalla, Kanoungto and Dawbong are considered separately. Questions of contamination of the water by the hydrated oxides of iron, and of vegetable and animal contamination

are also dealt with. The report includes a table of particulars of 419 tube wells with references to 117 strata logs in the possession of the Geological Survey of India. There is also a table of over a hundred analyses of water from tube wells in and around Rangoon. Accompanying the report are also numerous diagrams and horizontal geological sections, a geological map of Rangoon and three maps showing clearly the distribution of successful and unsuccessful wells. The appendix includes a short note with illustrations, by Mr. D. D. Crabbe, Assistant Engineer to the Port Commissioners, Rangoon, on the structure of the recent alluvium as revealed by numerous borings along the river bank.

Burma Underground Water Act, 1930.

79. The draft notifications which it is proposed to issue under sections 1, 2, 5 and 6 of the Burma Underground Water Act, 1930, to which attention was directed in the last Annual Report, were published during the period under review. The Government of Burma has extended all the provisions of the Act to the City of Rangoon and the districts of Hanthawaddy and Insein. It has also been declared that the Act shall apply to all tube wells exceeding a depth of 60 feet below ground level in these areas.

The notification proposes that copies of all temporary and permanent licenses granted under the Act, shall be forwarded to the Director of the Public Health Institute, to the Superintending Engineer of the Public Health Circle and to the Superintendent of the Burma Party, Geological Survey of India, Rangoon.

Rawalpindi district, Punjab.

80. Dr. Cotter was deputed in February to examine the borings made by the Agricultural Department at Khanna Dak and other localities in the Rawalpindi basin. The water-conditions of this basin have been already examined by this officer[1] and Mr. D. N. Wadia.[2] Dr. Cotter considers that artesian water will be found only in the vicinity of Khanna Dak, and that a policy of water-conservation should be adopted, (1) by keeping the borings fairly far apart, say at distances of a quarter of a mile, and (2) by providing each bore with a stop-cock, so that the water can be cut off when not required.

In April Dr. Cotter visited some wells at Kallar, about 25 miles south-east of Rawalpindi. Two wells had been deepened by boring into the Middle Siwaliks. Dr. Cotter recommended that Bh. Basant Singh's

[1] *Rec. Geol. Surv. Ind.* LXIII, p. 72, (1930).
[2] *Op. cit.*, LXV, p. 69 (1931).

well should be deepened by boring through the Siwalik clays, which dip at an angle of 45,° into the next lower bed of sandstone, but considers that, owing to the rather steep dip, the additional water made available will not be large.

Jhelum district, Punjab.

81. Mr. D. N. Wadia was asked to examine the possibilities of obtaining underground water at certain proposed sites in the drier parts of Potwar in the Jhelum district. The three villages of Lehri (33° 9′ : 70° 50′), Chak Gakhar (32° 58′ : 72° 48′), and Dani Dehra (32° 56′ : 73° 20′), stand on subordinate water-partings with deep ravines on either side, so that their water-supply will always be a difficult problem. Tube wells are not likely to be successful unless the boring is carried well below the level of the ravines, *i.e.*, about 300 ft., when considerable pumping will be necessary. Steps may, however, be taken to conserve the rain water by small dams across the numerous ravines and by means of tanks. No costly structures can, however, in the opinion of Mr. Wadia, be recommended for these, for the soft porous rocks of these localities are liable to permit enormous leakage from artificial reservoirs.

The belt of country lying further west, between Chakwal and Kariala from north to south, and between Bhaun (32° 59′ : 72° 45′) to Saidpur from west to east, has a geological structure very favourable for tube wells. The nearly horizontal beds of coarse sands will be found to be good carriers of underground water under imperfectly artesian or semi-artesian condition. Large-diameter wells also are likely to be successful. The rocks are alluvial clays and sands with pebbles, overlying Upper Siwalik strata, the beds being bent into a very shallow synclinal fold.

At Sohan (33° 4′ : 73° 26′) a large-diameter well of moderate depth is likely to tap a good supply, as the capping of coarse, soft, alluvial sands on the bed-rock of the country is of good storage capacity.

The village of Mangwal (33° 50′ : 72° 50′) is situated near the edge of a plateau with a steep scarp falling 250 ft. to the wide sandy bed of the Bhagne Kas. The bed of the Bhagne Kas is a good and infallible reservoir of water and supplies may be pumped from shallow pits with filter cribs, at the edge of the scarp, thus obviating the expense of speculative borings. The present deep dug well at Mangwal is a total failure, but there are a number of good wells on the Bhagne supporting a fair amount of agriculture by irrigation.

82. The water supply of the extreme eastern part of the Punjab Salt Range has already been discussed. Mr. E. R. Gee is now able to report upon the area between Kusak (32° 43′ : 73° 4′) and Dhak colliery (32° 36′ : 72° 30′) as the result of investigations carried out during the course of systematic field work in those areas.

Eastern Salt Range, Punjab.

In regard to the alluvial tracts of plain country to the south of the Salt Range, Mr. Gee observes that at least in those areas approaching the foot of the scarp, it is not so much a question of obtaining water, but of obtaining supplies of sufficient purity to be fit for human consumption and for agricultural purposes. All the main gorges of these slopes have eroded their courses through the Salt Marl deposits of the Range, and the drainage is, therefore—particularly after heavy rain—decidedly saline. Mr. Gee suggests that, by selecting sites for wells as far as possible away from these main drainage channels, the chances of the water being saline would be minimised. Regarding the reported encroachment of the saline alluvial tract to the south of Khewra (32° 39° : 73° 0′) and Dandot (32° 39′: 72° 58′) towards the Jhelum river east and west of Pind-Dadan-Khan (32° 35′ : 73° 3′), Mr. Gee is of the opinion that this may be largely due to the greatly decreased flowage of fresh water, in these lower portions of the Jhelum river, during recent times. He points out that, as a result of the tapping of the Jhelum river at Mangla (33° 8′ : 73° 39′) and Rasul (32° 42′ : 73° 33′) for purposes of irrigation, the amount of fresh water which now drains through the lower stretches of the Jhelum and the adjoining alluvial deposits to the south of the Salt Range has very appreciably decreased. This, Mr. Gee suggests, explains, at least to a large extent, the gradual encroachment of the saline tract towards the Jhelum river within the memory of many of the present inhabitants.

Alluvial plains south of the Salt Range.

In regard to the water supply of the scarp slopes of this portion of the Salt Range. Mr. Gee points out that the Nummulitic Limestones, which cap the slopes, and which vary from about 200 feet thick north of Kusak to over 300 feet in the Nilawan ravine, form the principal permanent reservoir. These limestones are underlain by relatively impervious shales; as a result, all the main fresh water springs which feed the various streams of the gorges, flow from the base of the limestone rocks. He observes that this spring water has been tapped in the Khewra gorge, and at Morjhang (32° 40′ : 72° 43′)

in order to supply the requirements of Khewra (32° 39′ : 73° 0′) and of Lilla (32° 33′ : 72° 45′) respectively. Other similar springs, near the top of the scarp, yield a large supply which might well be used to satisfy the needs of the inhabitants of the plains to the south of the Range.

The area west of the Karangal and Diljaba ridges, and north of the Dalwal (32° 42′ : 72° 53′) plateau is composed of Siwalik strata. Mr. Gee observes that the water supply of these tracts is derived from springs rising from the Nummulitics of the northern edge of the Salt Range plateau and from the Siwaliks to the north, from several of the larger *nalas* which intersect the area, and from wells sunk in the massive sandstones. He suggests that in many cases similarly located wells would yield a moderate supply of water,—sometimes slightly saline, though usually palatable—at moderate depth.

The Dalwal plateau, stretching from Choa Saidan Shah (32° 43° : 72° 59′) to beyond Kharder (32° 44′ ; 72° 47′) and northwards to Khajurla (32° 45′ ; 72° 59′) and Khokhar (32° 47′ ; 72° 49′) is composed of a number of east-to-west valleys in which the Nummulitic Limestones are overlain by a portion of the Kamlial succession or by alluvium. These valleys are separated by anticlinal or horst-like ridges of the Nummulitics. Mr Gee notes that the present water supply is either derived from springs issuing from the limestones, from large artificial tanks, or from wells sunk into the alluvial or Kamlial beds. Of these limestone springs the Katas (32° 43′ ; 72° 57′) spring feeds the Choa Saidan Shah stream, and during the annual fairs the water is filtered and piped down to Choa to meet the requirements of the numerous visitors. The water level in the alluvium and Kamlial beds of the Dalwal valley varies from a few feet up to over 100 feet. Mr. Gee notes that several wells excavated into the upper part of the Nummulitic Limestones have yielded no water, and in this connection he points out the futility of excavating such wells unless they are carried down to the *lower* horizons of the limestones. Were these lower horizons penetrated in the synclinal valley areas, Mr. Gee is convinced that they would tap large supplies of fresh water, in many cases under artesian or sub-artesian conditions. The limestones vary from 250 feet in the east to about 300 feet in the west of the area, and the advisability of bore-holes in some cases is advocated by him. In this connection he cites the case of a bore-hole which was put down some years ago with the object of proving the coal horizon beneath

the Nummulitic Limestones a short distance west of Tatral (32° 44′; 72° 56′). When the basal zones of the limestones were reached artesian water flowed from the well.

Mr. Gee notes that the Dandot plateau, and the Chittidand plateau just west of Makrach (32° 40′ : 72° 54′) are on Nummulitic Limestone basins, and that it is probable that good supplies of sub-artesian water could be obtained from the central parts of these areas, and also just north of Waralah (32° 41′ : 72° 50′), by bore-holes carried to a depth of about 250 feet.

The Sardahi-Bhuchal Kalan plateau further west is also a shallow basin, composed of the Nummulitics overlain by basal Kamlials and by alluvium. Mr. Gee notes that the villages between Sardahi (32° 42′ : 72° 43′) and Ransial (32° 3′: 4 : 72° 41′) obtain their supplies either from springs issuing from the Kamlials, from wells sunk in the latter beds or in the overlying alluvium, or from large tanks. In the case of the villages to the south and west the position is more acute. Regarding Bhuchal Khurd (32° 40′ : 72° 42′), Mr. Gee suggests the excavation of a well in the Kamlials to the north of the village, whilst for the villages of Bhuchal Kalan (32° 41′. 72° 38′) and Jhamrah (32° 43′ : 72° 37′) he advocates the digging of wells in the adjoining alluvium or the sinking of bore-holes—to a depth of from 250 to 350 feet—down to near the base of the limestones. Such bore-holes would, in his opinion, yield an excellent supply.

At the request of the Sub-divisional Officer, Boring Operations, Rawalpindi, Mr. Gee reported on the prospects of finding water by boring at Bhuchal Kalan (32° 41′ : 72° 38′), Kherdher and Thoa Humayun (32° 51′ : 72° 48′). The first two villages are within the tract referred to above, whilst Thoa Humayun is three miles east by south of Bhaun in the tract reported on by Mr. Wadia (see para. 81). At the first two localities Mr. Gee recommends shallow hand-dug wells in the alluvium; and only if these are unsuccessful does he recommend borings into the underlying limestone. At Thoa Humayun Mr. Gee thinks a deep bore into the Upper Siwaliks should prove successful, except for the possibility that the water may be saline.

Fall of water-table in Jullundur Doab, Punjab.

83. In April, Dr. Cotter visited the Jullundur Doab, at the request of the Punjab Government, in order to study the causes of the fall of the water-table in the Hoshiarpur and Jullundur districts.

[1] *Rec. Geol. Sur. Ind.*, LXIII, pp. 75-78, (1930).

Since 1908, the fall in the water-table has been a matter of increasingly grave concern to the Punjab Government. It had been suggested that the earthquake of April 4th, 1905 might have been a contributary cause of the fall. Dr. Cotter is of opinion that this is not so, since the evidence recorded on the files shows that the fall was gradual and that the depletion surface follows the intensity of irrigation from wells. The account of the earthquake by Mr. C. S. Middlemiss shows that there was no sharp fall in the water-table after the earthquake, but that on the contrary the effect of the quake was generally to loosen the soil, and render the outflow of springs generally more copious. The two main causes of the fall are generally agreed to be decrease in rainfall and increase in wells used for irrigation and increase in well-irrigated or *chahi* land.

The cause of the decrease in rainfall may be connected with the deforestation of the Siwaliks. At the same time, this deforestation has resulted in the flow of surface water being no longer regulated by the presence of forests; the river Eastern Bein and the *chos* (torrent-channels) of Hoshiarpur are more subject to sudden floods than formerly, due to the intenser run-off in deforested land.

The increase in wells and in *chahi* cultivation places a two-fold strain upon the ground-water, in that the demand upon it is higher, while the percolation of rainfall is reduced by a more active evaporation.

It is asked whether the deficiency in water can be made up by exploiting the deeper water-sands, as for instance that which is frequently found about 200 feet below the surface. Dr. Cotter thinks that the deeper sands are in hydrostatic connection with the ground-water, because :—

(1) the hydrostatic pressure appears to be the same;

(2) it is to be assumed that the beds of rapidly alternating sand and clay which make up the bulk of the Indo-Gangetic alluvium are not continuous sheets, but viewed broadly, of a lenticular type and discontinuous, permitting of a permeable passage downwards;

(3) the Indo-Gangetic alluvium has been shown by drilling experience to be a weak incoherent deposit, such as could not reasonably be expected to be capable of effectually separating two water-strata under differing pressures,

(4) the upper and lower sands are already connected by perforated pipes in a great number of wells.

The water-table will therefore probably continue to fall, whether water is drawn from above or below.

It may be noted that deep sands do not contain so much water generally as those near the surface, by reason of the closer packing of the sand-grains due to the superimposed weight. In addition, the exploitation of water sands below 600 or 800 ft. in depth is probably difficult owing to blows of sand or mud that choke the well.

The question of well interference becomes important when deep sands are worked, and a vigorous exploitation of the deep sands might lead to serious loss of money through a decline in yield due to well interference.

Dr. Cotter agrees with the proposals of Mr. Robertson, Superintending Engineer, Waterlogging Investigation Circle, Lahore. The latter officer recommends the construction of low embankments ('*wats*') in rain-crop or *barani* land, so as to minimise run-off, and suggests that some means of utilising the flood water of the Eastern Bein might be adopted.

Wolfram.

Yawnghwe State, Southern Shan States, Burma.

84. On the western flanks of hill 4,832 to the east of Pawlamaw (20° 37′ : 96° 52′) and near the southern end of the Heho-Mawnang plain, there are numerous dumps from old trenches and pits which were formerly worked for wolfram. According to Dr. Coggin Brown, the country rocks are mainly hard, fine-grained, silt-stones crossed by thin quartz stringers and veinlets. The quartz is granular and crystalline, exhibiting irregular vugs with pyramidal quartz terminations. The veinlets contain muscovite mica, either lining the vugs or segregated into patches, or, more often, forming a thin wall between the quartz vein and the host rock. Wolfram occurs in thin plates and crystals irregularly distributed through the quartz. It is usually profoundly decomposed or even completely removed, leaving empty spaces, sometimes filled with cindery oxides of iron and manganese and rarely showing a film of tungstite. There are no surface rock exposures in the vicinity, which is covered with a thick layer of orange-red clayey soil. Higher up the hill tabular limestones of the Heho series with argillaceous partings dip W. S. W. at 35°. These limestones are more saccharoidal than the typical varieties and sometimes contain white mica—a result perhaps of

the local intrusion of the quartz-mica-wolfram veins and stockworks. Judged from the distribution of the old workings, the latter occur in a broad zone running approximately north and south and a few hundred feet wide. Small quantities of pyrite, now changed into limonite, are the only other metallic mineral visible.

Jodhpur State, Rajputana.

85. In December Dr. Heron revisited the wolfram mine at Rewat (26° 54′ : 74° 19′), near Degana Junction on the Jodhpur Railway. He had examined it shortly after its discovery in 1913[1], and Sir Henry Hayden visited it in 1915[2].

The average annual output of the four war years 1916 to 1919 was about 40 tons, but since then no output has been registered, though work has been going on, and the local representative of the lessees, a Gujarat firm, informed Dr. Heron that 8½ tons had been produced in 1929 and 9 tons in 1930.

The Rewat hills consist of granite, probably the Idar granite of Middlemiss, of Malani age, intruded into Aravalli phyllites. Topaz is a noteworthy accessory. Penetrating the granite are many veins of quartz and biotite, six to eighteen inches wide, usually vertical and with a N.W.—S.E. strike. The quartz and biotite are disposed in bands parallel to the walls of the veins, the biotite frequently, but not always, next the walls, and the wolfram is developed in bladed and tabular crystals indiscriminately in both quartz and biotite. Flourite is common in the veins and the phosphates triplite and libethenite have been detected.

GEOLOGICAL SURVEYS.

Assam.

86. During the Durga Puja holidays of 1930, I paid a brief visit to the Badarpur and Digboi oilfields in Assam for the purpose of discussing with Mr. Sale of the Assam Oil Company the results of their geological mapping of recent years. As a result of this visit Dr. Chhibber, who was to accompany another Hukawng Valley expedition, was sent to Assam for the purpose of obtaining some familiarity with the Assam Tertiary formations as classified by the Assam Oil Co. Mr. Percy Evans very kindly showed him some of the principal sections and an arrangement was made by which Dr. Chhibber was to re-

[1] *Rec. Geol. Surv. Ind.*, XLIV, p. 26, (1914).
[2] *Op. cit.*, XLVII, p. 26, (1916).

enter Assam from the Hukawng Valley and compare notes with Mr. Evans on the Assam-Burma frontier. Unfortunately, however, the Hukawng Valley expedition had to be abandoned on account of disturbances in other parts of Burma.

The work of the Assam Oil Company has shown how important are the methods of sedimentary petrography in the identification and correlation of the Tertiary strata of Assam. Although Dr. Chhibber was prevented from returning to the Hukawng Valley whilst his memory was still fresh from the Assam sections, yet he had been to the Hukawng Valley and the adjoining Jade Mines tract in previous years. A suite of some 80 samples of arenaceous rocks collected by him, mainly from the Jade Mines tract just to the south of the Hukawng country, was accordingly submitted to Mr. Percy Evans for examination. The samples were examined by Mr. Majeed under the direction of Mr. Evans who has kindly submitted a report thereon. Mr. Evans finds that the mineral assemblages in the slides prepared from these samples show considerable resemblances to those of Assam. He is able to compare certain slides with those from the Tipam, Surma and Barail series of the Assam Oil Co. and Mr. Evans is of opinion that similar methods of study applied in Upper Burma would prove of value in the correlation of different areas of Tertiary rocks.

Bihar and Orissa.

Gangpur State.

87. Only one officer was available for field work in Bihar and Orissa during the field-season 1930-31, namely Dr. Krishnan, who continued his systematic survey of Gangpur State, Bihar and Orissa, and completed the most westerly part of the State lying in sheet 64 O/N.E., N./S.E. (scale 1 in. = 2 miles) up to the boundary of the Gondwana rocks that occupy the south-west portion of that sheet. In addition, Dr. Krishnan completed some unmapped areas in the south-eastern part of the State in sheet 73 F/4 (scale 1 in. = 1 mile) and continued into sheet 73 F/3 (scale 1 in. = 1 mile) in the Singhbhum district, thus linking up his work in Gangpur with the recent surveys of west Singhbhum. In all, an area of about 350 square miles was mapped.

In western Gangpur the area covered falls into two physiographical divisions—a southern plain of an average height of 800 to 900 feet above sea level and a northern, more broken area about 300 feet higher. The two areas are separated by a ridge of quartzites or micaceous quartz schists which passes immediately north

of Sarapgarh (22° 11′: 83° 45′) and dips in a southerly direction. The northern portion is composed of mica-schists with a few sills of epidiorite, and the southern of mica-schist abundantly penetrated and partly assimilated by granite, with a few prominent ridges of micaceous quartzites. The strike of the rocks in this region is approximately N.W.—S.E., varying to W.N.W.—E.S.E., the dips being generally high. The chief interest in this area lies in the occurrence of a bed of crystalline limestone in the *nala* just north of Lifripara (22° 7′: 83° 49′) which seems to be the westerly continuation of the exposures of similar rocks near Bhasma (21° 58′: 84° 2′).

Gondwana rocks overlie the crystallines; the boundary between the two is irregular and indicates that it is one of original deposition. Along the boundary Talchir rocks occur in the south-east and Barakar sandstones in the north-west; they dip at low angles (10° to 25°) towards the south or south-west.

The most westerly occurrences of the gondite series of rocks in Gangpur State are near Ghoriajor (22° 3′: 84° 8′), and are overlain by mica-schists and phyllites followed by calcitic and dolomitic marbles. These latter rocks can be traced along the Sapai *nadi* from a point east of Ghoriajor to the junction of the Sapai *nadi* and the Ib river near Bhasma, and in these exposures the strike of the marbles changes from N.E.—S.W. to E.—W. Although the area intervening between Bhasma and Lifripara is alluvial, with isolated exposures of granite and mica-schist and no crystalline limestone, it seems certain that the rocks found in these two series of exposures are identical, the strike having swung round from E.—W. near Bhasma to W.N.W.—E.S.E. near Lifripara. This W.N.W.—E.S.E. strike continues to the westwards, rendering probable the view that the gondite and crystalline limestone occurrences of Gangpur may be correlated with those of the Central Provinces.

In the eastern area, in the region south of Bisra (22° 15′: 85° 0′), occur phyllites with a bed of intercalated carbonaceous rocks, whilst a ridge of sheared schistose conglomerate marks the Gangpur-Singhbhum boundary. To the north and north-west of Manoharpur (22° 22′ 30″: 85° 12′) phyllites and mica-schists are also found, these being intermediate in grade of metamorphism between the shaly phyllites occurring in south-western Singhbhum and the mica-schists in eastern Gangpur.

The succession exposed in Gangpur seems to be older than the Iron-ore series of Singhbhum, although no definitely recognisable unconformity separates the two. The sheared conglomerate horizon may however indicate some vertical movement.

88. During the field-season 1930-31 the Burma Party consisted of Dr. J. Coggin Brown (in charge), Messrs. C. T. Barber, A. K. Banerji, P. Leicester, V. P. Sondhi, B. B. Gupta, H. L. Chhibber, and M. R. Sahni. During the recess season when Dr. Coggin Brown was on leave. Mr. A. L. Coulson officiated as Superintendent and was placed in charge of this party.

Burma Party.

89. Dr. H. L. Chhibber spent the months of February to May, 1931, in mapping parts of sheets 92 C/14, C/13, C/6 and C/7 in the Myitkyina district. He recognised the following rock series and types :—

Myitkyina district.

VIII. Alluvium.
VII. Uru boulder conglomerate.
VI. Namting series.
V. Hkuma series.
IV. Crystalline schists.
III. Altered peridotites and serpentines.
II. Granite and ortho-gneiss.
I. Limestone.

Two small outcrops of *limestone*, almost metamorphosed to marble, occur in the neighbourhood of Tanaibum Ga (25° 54' : 96° 55'). The bigger of the two is about a quarter of a mile W. S. W. and the second about half a mile north-west of the village. The limestone is quite thin and of a very fine granular texture.

Granite and ortho-gneiss with the same characteristics as those described in the General Report[1] for 1929, was found forming low hills near Lawsun (25° 18' : 96° 27'), which continue as far as Manwe (25° 25' : 96° 34').

Altered peridotites and serpentines were mapped on sheets 92 C/14, C/13 and C/7. On the first sheet these rocks form the small hill marked 657 *en route* to Lawa (25° 33' : 96° 47'). On sheet 92 C/13 several small outcrops occur among the crystalline schists. Beginning from the north two small outcrops were found in the

[1] *Rec. Geol. Surv. Ind.*, LXIII, pp. 98-99, (1930).

neighbourhood of Tanaibum and a bigger one about 3/5 of a mile south-west of it. A small and irregular outcrop occurs a little east of Mupaw (25° 52′: 96° 53′). On the biggest outcrop are situated the villages of Mah-kyetkawng (25° 50′: 96° 53′) and Kawnan Ga (25° 51′: 96° 53′). Several other occurrences are found west of 'Nhpum (25° 15′: 96° 51′). In several places a band of altered peridotites and serpentines runs along the junction of the crystalline schists and the Hkuma series described below and occasionally the serpentine is very highly brecciated, most probably marking a line of faulting. On sheet 92 C/7, these rocks were traced southwards as far as Kawabum (25° 21′: 96° 20′).

The *crystalline schists* occupy considerable areas of sheets 92 C/14 and C/13. Beginning from the boundary of the Kamaing subdivision, near the deserted village of Kadakawng (25° 32′: 96° 49′), they continue to the northern edge of the sheet. Towards the east they were mapped as far as the eastern limit of the subdivision, which is here marked by the Sellen and Tanai Hkas. They were followed northwards to the boundary of the unadministered territory of the Hukawng Valley on sheet 92 C/13. Their constitution is identical with that described in the General Reports[1] for 1928, 1929 and 1930. During the present season however, besides the usual members of the graphite-, mica-quartz-schists, epidiorites, etc., a coarse-bedded porphyritic granitic gneiss, which is interbedded with the crystalline schists, was observed in the Saga Hka, a stream which joins the Hkara Hka about one furlong from the latter's confluence with the Tanai Hka. The gneiss shows a very varying texture from that of a fine-grained schistose rock to that of a coarse granite-gneiss. In the Tanai Hka near its confluence with the Hkara Hka, it assumes the aspect of a micaceous schist, being very finely bedded and dipping north-east at high angles. It is also highly jointed and cleaved into small pieces. In places, however, the dip is vertical, the rock is very crumpled and shows evidence of minor strike faulting. Similar porphyritic, schistose gneiss was observed in the Magrwe Bum.

Quartz is intrusive into the schists as small and big veins, lenses and lenticles with varying thicknesses from that of paper to several feet across. Sometimes blocks of quartz, over five feet in diameter, were seen lying on the surface.

[1] *Rec. Geol. Surv. Ind.*, LXII, pp. 110-111, (1929); LXIII, pp. 99-100, (1930); LXV, p. 78, (1931).

Dr. Chhibber has divided the *Tertiary rocks* of the area as follows:—

(3) Uru boulder conglomerate.
(2) Namting series.
(1) Hkuma series.

This classification supersedes the tentative one mentioned in the General Report[1] for 1929, which was based on the exploration of a very small area.

Good sections of the *Hkuma series* are exposed along the Shadu, Tagam, Hkuma and Hkada streams, of sheet 92 C/13. In the Shadu Hka, almost from its source to its confluence with the Sumpra Hka, they show a northerly dip which, however, fluctuates between north-west and north-east. Distinct cross folding was observed in places. The angle of dip varies from 30° to 90°, the average, however, being about 45°. Sandstones with occasional interbedded layers of shales or argillaceous sandstones are predominant. In places they are finely laminated, while in others they are coarse and pebbly. The most remarkable feature about these sandstones is their extremely well-bedded character, for almost every outcrop shows both direction and angle of dip distinctly. They are greyish, greenish, whitish, pale-yellow or reddish in colour, sometimes with black carbonaceous streaks. In the Shadu Hka alone, about 10,000 feet of them are exposed. In the Tagam Hka, sandstones were seen interbedded in places with black carbonaceous shales which are sometimes very friable. These sandstones and shales both contain well-preserved fossil leaves, specimens of which were collected from the Hkada Hka (25° 50′ 15″: 96° 51′ 30″) and the Tagam Hka (25° 55′: 96° 51′).

On sheet 92 C/13 their junction with the crystalline schists and serpentines is faulted, as shown by the brecciation of the latter rocks in the Hkuma and the Hsamshing Hkas. On and near the contact the streams suddenly go dry and the water reappears a little lower down. Similar rocks were also met in the upper course of the Namjan Hka, on sheet 92 C/5, and the upper portion of 92 C/6. Specimens collected during the previous seasons showed that their heavy mineral assemblages correspond with those of the Barail series (Eocene-Oligocene) of Assam.

[1] *Rec. Geol. Surv. Ind.*, LXIII, p. 100, (1930).

The Upper Tertiary rocks of the *Namting series* seen on the mule track between Namting (25° 38′: 96° 27′) and Lonkin (25° 39′: 96° 22′) and containing fossil wood, were described briefly in the General Report[1] for 1928. Specimens collected from them, with very few exceptions, yielded heavy minerals which, according to Mr. P. Evans of Digboi, agree closely with those from the Tipam series of Assam. Similar rocks were observed in the Tarong Hka near Tarongyang (25° 40′: 96° 15′). The Tertiary rocks forming the low hills near Nanyaseilk (25° 37′: 96° 35′) also belong to this series.

A brief account of the *Uru boulder conglomerate*, which is jadeite-bearing in places, was given in the General Report[2] for 1928. Last season Dr. Chhibber mapped its junction with the Namting series in the neighbourhood of Hpakan (25° 36′: 96° 18′). It is mainly a conglomerate formation consisting of boulders which must have been partly deposited by the Uru (Uyu) river or its bigger predecessor, but more largely by the torrents descending from the hills on the west flowing into it. Dr. Chhibber collected samples of this formation, especially from the lenticles of sand-rock occurring in the conglomerate. Mr. P. Evans of the Assam Oil Company, Limited, Digboi, who kindly examined their heavy residues, arrived at the conclusion that the heavy minerals of this group were distinct from the two lower groups of the Tertiaries, *viz.*, the Hkuma series and the Namting series, described above, and were marked by the absence of tourmaline, garnet, zircon and rutile.

Myitkyina district. Traverses.

90. During field seasons 1929-31 Dr. Chhibber made traverses between Myitkyina and the Hpimaw, Lagwi and Panwa Passes on the Chinese frontier of Burma and mapped parts of sheets 92 G/11, G/15, G/14, 92 K/1, K/5, K/6, K/9, 92 J/8 and J/12. He recognised the following series and rock-types :—

(12) Alluvium and recent boulder deposits.
(11) Volcanic tuffs.
(10) Basalt and associated rocks.
(9) Dolerite dykes.
(8) Gabbro.
(7) Granodiorite.

[1] *Rec. Geol. Surv. Ind.*, LXII, pp. 109-110, (1929).
[2] *Op. cit.*, LXII, pp. 112-114, (1929).

(6) Granite.
(5) Epidiorites.
(4) Chlorite schists.
(3) Granite-gneiss.
(2) Limestone.
(1) Pyehpat shales.

Greyish shales crop out near mile 64 on the Htawgaw road and continue, with several small intrusions of gneiss, as far as the Ngawmawnlang Hka building the core of the Pyehpat range, about 7,000 feet high above sea-level, where it is crossed by the Htawgaw road. They are best developed in the neighbourhood of the Pyehpat Inspection Bungalow (25° 56′ : 98° 15′) and have hence been called the *Pyehpat shales*. They are generally greyish-black in colour when fresh. On the western side of the range they are folded but on the eastern side they show a general westerly dip. They are unfossiliferous and lithologically are not unlike the Chaung Magyi slates of the Shan States. Similar shales crop out again near mile 120 on the Hpimaw road and continue as far as the P. W. D. Inspection Bungalow at Hpimaw (26° 0′ : 98° 38′). They were also traced further south, about four miles S. S. E. of Chu-iho (25° 57′ : 98° 38′) on the Fenshuiling Pass road, where they are overlain unconformably by limestone, highly brecciated in places and probably of the same age as the Plateau Limestone of the Shan States.

Limestone, metamorphosed and almost converted into white marble, is seen after crossing the Ngawmawnlang Hka, and extends to about ¼ mile north of mile 71 on the Htawgaw road. It again builds the top of what is locally called the Langyang range, commencing a little south of its summit where it is crossed by the Htawgaw road. The next big outcrop, where it overlies the shales, north of the Lower Hpimaw village (26° 0′ : 98° 37′), builds hills over 8,000 feet high. It was traced southwards with some breaks, apparently due to denudation, as far as a point about four miles S. S. E. of the village of Chu-iho, where it forms the 8896 pass on the Fenshuiling Pass road. Opposite and north-west of Chu-iho it forms very well-marked cliffs.

Granite-gneiss, which is mainly a biotite gneiss, occurs near the Tangahka Bungalow (25° 43′ : 98° 56′) and continues as far as a little east of mile-post 64 on the Htawgaw road. It builds

very rugged ranges, 'knife-edged' ridges with equally sharp spurs, high, rounded or conical peaks and small domes.

It is injected with pegmatitic, aplitic and quartz veins.

Chlorite-schists were first observed about half a mile S. S. W. of mile 27 on the Htawgaw road and extend in a south-south-westerly direction for a little over two miles. Another outcrop of similar schists was seen near the suspension bridge after leaving the Tangahka Bungalow. These schists are well-bedded and are intruded by quartz veins.

Epidiorites first crop out about half a mile south-west of the Inspection Bungalow of Seniku (25° 32′: 97° 48′) and were traced for over 22 miles along the Htawgaw road, as far as a little west of the Tangahka Bungalow. From Shingaw (25° 39′: 97° 53′) they were mapped as far as Tingsayang (25° 38′: 97° 55′) and Chingma (25° 37′: 97° 53′). The type-rock has a crude gneissic structure and crystals of green hornblende are predominant. A specimen of serpentinised pyroxenite, apparently a basic modification of the epidiorites, was collected from the right bank of the Shingaw Hka, where it is crossed by the Sawlaw-Chingma path.

Granite occupies the greater part of sheet 92 K/5. It is first met on the Htawgaw road after crossing the Langyanglaw Hka and was traced as far as the northern and eastern limits of the sheet. Beyond Htawgaw (25° 57′: 98° 22′) it was traced as far north-eastwards as mile 120 on the Hpimaw road. South-eastwards it stopped only about half a mile short of the Lagwi Pass, 8,850 feet above the sea. It again crops out near the Inspection Bungalow at Hpimaw (26° 0′: 98° 38′) and was traced as far as the Hpimaw Pass, 10,338 feet above the sea.

Further south it was traced as far as about 3½ miles S. S. E. of Chu-iho (25° 57′: 98° 38′) *en route* to the Fenshuiling Pass. It builds very rugged and broken hills, exceeding 12,000 feet in height. The rock is a very coarse biotite-granite, which in places has been injected by veins of graphic and aplitic granite, while quartz veins are fairly common.

Granodiorite sets in about half a mile after crossing the suspension bridge on the Namyin Hka near Wausawng (25° 22′: 97° 35′) and continues for about two miles on the Waingmaw-Seniku road, parallel to the Namlau Hka. The rock is mostly a quartz-diorite with glistening crystals of hornblende, but in places its acidic modification, almost approaching a granite, is also seen and usually bears

a reddish, in places a lateritised, soil. The same rock is met with again about a mile S. S. W. of the P. W. D. Inspection Bungalow near the 20th mile on the Seniku road and continues as far as the alluvial plains of Man Ming (25° 29′ : 97° 44′). Sometimes the rock is well-bedded, but more commonly it is massive with coarse joints. About 1½ miles S. S. W. of Wuman (25° 26′ : 97° 41′) its acidic modification is exposed and here the proportion of quartz in hand-specimens inclines one to class it with granite, in the absence of chemical analysis. The granitic rock yields a light-coloured sandy soil.

Gabbro crops out about half a mile east of Seniku (25° 33′ : 97° 47′), and Numkai (25° 35′ : 97° 47′) and the deserted village of Hkinrawng (25° 35′ : 97° 45′) are situated on it. It also builds the Loingu Bum, 4,186 feet, and the Waga Bum. From the village of Hkinrawng it was traced as far north as the 'Nmai Hka. Southwards it extends as far as mile-post 27/4 on the Seniku road.

At least nine *dolerite dykes*, running in a N.W.—S.E. direction, were observed at the confluence of the Mating and Pyawhkaw Chaungs, between miles 103 and 104 on the Hpimaw road. The maximum width of a dyke measured about three feet, while the exposed length was about 100 feet. Evidently they are intruded into the granite along the joint planes, since subsidiary dykes, from less than an inch to a few feet thick, were seen bifurcating from the main ones and running again parallel to the latter. Near the contact, xenoliths of granite occur in the dolerite. In places, these dykes are affected by minor strike faults.

Volcanic tuffs were first observed on the Seniku road, about half a mile south of Tawngpaw (25° 24′ : 97° 38′) and continue as far as about 1½ miles S. S. W. of Wuman. They are very highly and irregularly jointed, as a result of which they not infrequently fall into small irregular pieces. They are generally dark-coloured, but reddish, whitish and yellowish shades are not uncommon. Sometimes epidote veins with quartz occur.

An outcrop of *basalt* was found at the village of Wuman (25° 26′ : 97° 41′) and with its associated tuffs was observed to extend as far as Singkat (25° 28′ : 97° 41′).

The Inspection Bungalow of Wausawng, near the 11th mile on the Seniku road, is built on a small hill, composed of greyish, close-textured *granophyre* with phenocrysts of quartz. Some of the specimens showed streaks and fine veins of iron pyrites.

The Mogok Stone Tract, Katha district.

91. A new topographical map on a scale of 4 inches = 1 mile, of the Mogok Stone Tract comprised between latitudes 23° 30′ and 22° 50′ and longitudes 96° 22′ and 96° 35′, is in course of preparation and pending its completion Mr. A. K. Banerji commenced work on Burma Forest Survey Sheets Nos. 285 $\frac{\text{N. W.}}{1}$ and 285 $\frac{\text{N. W.}}{3}$.

The rocks met with were classified into the following groups:—

Mogok series.
Acid gneiss.
Syenites and nepheline rocks.
Minor intrusions.

The Mogok series seems to be the oldest in the area and represents a highly metamorphosed series, partly of sedimentary origin. The true relationship of the acid gneiss to it can only be established by further work when the structure has been elucidated; at present no exposure showing the contact between the two is available, but tentatively it is regarded as intrusive into the Mogok series. If this prove to be correct, the problem will be, as in the case of South India, to find the basement on which the rocks of the Mogok series were deposited. The alkali rocks and the granite pegmatites are taken as the latest phases of the intrusion and the reason for grouping them together is that alkali felspar with moonstone schiller occurs in both of them.

Along the Kyini Taung-Myo Taung ridge, which lies to the east of the town of Mogok, good exposures are seen which give the sequence in the Mogok series. The rocks met with in descending order commencing from the Kyini Taung end are as follows:—

Garnet-biotite-gneiss, sometimes with sillimanite.
Garnet-granulite,
Augite-gneiss,
Calciphyre,
Limestone,
Calc-gneiss,
Limestone with pegmatite,
Calc-gneiss,
Limestone,
Calc-gneiss.

The garnet-biotite-gneiss with or without sillimanite is a thick, massive formation and constitutes the solid geology of the ridge to

the south-east of the Mogok valley known as Nankaung Taung and Zalatni Taung. Myintada Taung on the south-west of Mogok is also formed of this rock. By alteration through subaerial weathering it gives rise to the red soil so characteristic of the area. In road cuttings the decomposed rock shows numerous stringers of aplitic and pegmatitic material injected into it, but now changed to kaolin and quartz. In Kyaukwa Kyaw ridge this rock passes into garnet-graphite-sillimanite-rock, quartz-sillimanite-rock, and iron-stained quartzite.

The calc-gneiss is usually diopside-gneiss and resembles similar rocks from the Archæan of Peninsular India. In some cases it shows the presence of graphite. The silicate minerals in the calciphyres are commonly diopside, phlogopite, and forsterite. In the course of this season's work chondrodite was found in the limestone of the Mogok series. On the Bernardmyo road, about three miles from Mogok, during blasting operations through a bed of limestone for a new alignment of the road, a band in the rock was exposed showing brownish-yellow grains of chondrodite associated with forsterite and spinel. The characteristic pleochroism of chondrodite is seen only in moderately thick sections and in crushed grains, but one section shows beautiful repeated twinning, which distinguishes it from forsterite, for which it is apt to be mistaken.

With the Mogok series are associated beds of garnet-granulite and pyroxene-gneiss. The former rock consists of garnet, quartz and felspar, which is mostly microperthite. It probably represents a phase of aplitic and microgranitic intrusion related to the acid gneiss. In some cases garnet is absent but on the other hand there is a type in which very fine biotite flakes come in, in addition to garnet. The rock is used for building purposes in Mogok as it can be easily worked, owing probably to the partial kaolinisation of the felspar. A fact worth recording is that in places where gemstones are worked, boulders of these rocks are very often present.

The augite-gneiss found in the section on the Myo Taung shows under the microscope quartz and labradorite, besides augite; the accessories are sphene, apatite and zircon.

The acid gneiss is exposed on the hill south-east of the village of Kyauknaga Yaw (22° 57′ : 96° 30′ 30″). It is a medium-grained rock, light in colour, showing incipient gneissic banding. The felspar is chiefly microperthite considerably altered to kaolin along the albite lamellæ. Occasionally a little oligoclase is visible and quartz

is abundant. The rock is poor in dark minerals; brown biotite is the only ferromagnesian mineral present, but in one instance garnet was noticed. The accessories are sphene, apatite and zircon.

The more important intrusions of *syenites* are confined to the neighbourhood of Kyaukthinbaw Taung and to the area immediately to the west of it. There is a large laccolitic intrusion north of the village of Oongain, a peculiar feature of which is that bands of limestone seem to be caught up in it. Only in one place is a contact seen and the rock next to the limestone is of a monzonitic type with gneissic banding rather rich in ferromagnesian minerals. The constituent minerals are oligoclase, microperthite, biotite, augite, with apatite as an accessory. The contact as exposed is very clear and sharp. This rock traced upwards to the top of Kyaukthinbaw Taung passes into augite-syenite. The syenite in the immediate neighbourhood of the limestone bands does not show any special feature; the rock is perhaps a little richer in pyroxene and shows gneissic banding due to the parallel arrangement of the pyroxene crystals.

The syenite is usually augite-syenite. Most of the felspar is microperthite, but a little orthoclase and albite are invariably present. The pyroxene is either augite or ægirine-augite. It sometimes shows closely packed thin parallel bands of dusty material which are black by transmitted light and white by reflected light. In some cases there are two sets of bands at right angle to each other. Two specimens show the presence of brown hornblende, in one of which biotite was present in addition. The accessories are sphene, apatite, and zircon. In one type of the rock some of the felspar crystals show a beautiful moonstone schiller. In thin section no microperthitic lamellæ could be detected in the crystals.

North-west of the Lishaw village of Chaunggyi (22° 58′ : 96° 32′) there is a small exposure of a *nepheline-rock* very rich in dark minerals. Its exact field relations are obscure, the ground being covered with soil and thickly forested. There is a prominent granite-pegmatite close to it on the north-east and on the other side a small exposure of limestone. No contact is visible, but the nepheline-rock appears to be an independent intrusion. In one place a small exposure was found that appears to be a segregation of the dark minerals of the rock. Including this, there are three rock types as follows :—

1. Jacupirangite.—A melanocratic rock very rich in dark minerals which are titanaugite and brown basaltic hornblende. The other

minerals are nepheline, orthoclase, plagioclase, calcite, with iron-sulphide and apatite as accessories. This rock differs from that of the type locality in containing felspars and hornblende.

2. Ijolite.—A rock without felspar. The minerals are nepheline, titanaugite, and brown basaltic hornblende. Sometimes the nepheline occurs in masses as large as the fist, without any crystal forms. This rock differs from that of the type locality in containing titanaugite instead of ægirine-augite and in containing hornblende.

3. Titanaugite-hornblende-rock.—The hornblende is a basaltic variety.

Near the same locality an interesting rock was found in the form of scattered boulders in a working for sapphire. It is a sapphire-bearing rock, a nepheline-corundum-syenite, and though a careful search was made, it was not possible to trace it *in situ*. The constituent minerals are nepheline, orthoclase, albite, blue corundum or sapphire, green spinel or ceylonite, and augite. The nepheline in places shows graphic intergrowth with felspar and the augite has glomero-plasmatic texture. In the same neighbourhood a nepheline-augite-syenite occurs in association with limestone. Some of these nepheline-rocks bear a close resemblance to the Sivamalai series of elæolite-syenites and corundum-syenites of the Coimbatore district of Madras described by Sir T. H. Holland[1].

The limestone bands of the Mogok series are found in many instances to be intruded by *veins of felspar-rock and granite-pegmatites* showing the development of interesting minerals at the contact. In one case a felspar-rock is intruded into coarse-grained limestone at Sontabe Taung, north-east of Mogok. The vein is 6 to 8 feet thick, and is composed of coarsely crystalline felspar, mostly albite. The only other non-felspathic mineral present is apatite. At the contact is developed a coarsely crystalline rock composed of nepheline, diopside, calcite, felspar, and apatite. This nepheline-bearing contact rock is evidently the result of interaction of the felspar-rock with limestone. This contact metamorphic phenomenon indicates that there has been desilication of albite as a result of assimilation by the magma of calcite-dolomite material. (Mogok limestones usually carry a small percentage of dolomite.) At the margin a certain amount of calcite and dolomite was assimilated by the magma and during consolidation the available silica was first used to satu-

[1] *Mem. Geol. Surv. Ind.*, XXX, p. 169, (1901).

rate the calcium and magnesium molecules with formation of diopside, which was the first mineral to crystallize out, as shown by the perfect crystal forms exhibited by it. After crystallization of diopside there was, it appears, a deficiency of silica, and nepheline instead of albite was then formed.

Another instance of a contact metamorphic phenomenon is found on the south-western slope of Myo Taung about four miles E. N. E. of Mogok. Here a granite-pegmatite vein is seen in contact with limestone. The pegmatite vein is several feet thick and is composed of quartz and felspar. The major portion of the felspar is orthoclase, only a few grains of albite being present. The only other mineral is graphite in the form of sporadic flakes. The limestone takes the form of white saccharoid marble with a little graphite and phlogopite. The contact rock is less than a foot in width and is composed of scapolite, diopside, felspar, calcite and some flakes of graphite. The scapolite shows numerous acicular inclusions of an opaque mineral which are arranged parallel to the *c* axis. The band of limestone is fairly pure and contains, with the exception of sporadic phlogopite, no siliceous impurity, neither diopside nor scapolite being present. The scapolite-bearing contact rock is apparently due to the interaction of limestone with magmatic material derived from the granite-pegmatite. Phlogopite usually carries a little fluorine and its presence in the limestone indicates that there has been pneumatolytic action on a subordinate scale. The felspars of a granite-pegmatite on Myo Taung exhibit a remarkable schiller and the rock was formerly worked for moonstone.

Northern Shan States.

92. Dr. Sahni continued the survey of the Northern Shan States and completed the mapping of sheet 93 E/11 and about one-half of sheet 93 E/15. Two formations were alone met with, namely, the Plateau Limestone and a series of rocks corresponding to the Namyao beds. In its lithological characters the Plateau Limestone is in no way different from that described last year from the adjoining area, and consists of massive dolomites of a whitish grey colour. The limestones are so completely dolomitised that all traces of organic remains have been obliterated. Furthermore, the entire dolomite series is so uniform in character that it was not possible to sub-divide it.

The formation equivalent to the Namyao beds consists dominantly of fine to coarse-grained purple sandstones with occasional beds of shale, generally dipping at high angles. Interstratified

among the sandstones are a number of limestone bands striking in an approximately N. E.—S. W. direction. For the greater part the boundary between the Plateau Limestone and the Namyao beds more or less follows the direction of this strike.

The sandstones have so far been found to be unfossiliferous, with the exception of a few indeterminable fragments of lamellibranchs. The limestones are argillaceous in character and are the only beds of Jurassic age in the area that have yielded a prolific fauna. Dr. Sahni reports the discovery of about a dozen new fossil localities. Among others the genera *Holcothyris*, *Burmirhynchia*, *Pecten*, *Alectryonia*, *Modiola*, etc., are represented; but species belonging to the first two genera are the most common.

Although the dolomites themselves are entirely unfossiliferous, Dr. Sahni discovered a very interesting fauna at Na Hkyam, in a series of thin-bedded argillaceous limestones and shales interstratified amongst them. The chief interest of this fauna lies in the presence of ammonites. Moreover, whereas brachiopods have formed the chief element in the faunas previously recorded from the Plateau Limestone, in the present instance these are entirely absent. In addition to the ammonites, gastropods are present in large numbers. Thus the composition of the Na Hkyam fauna is totally distinct from that of the faunas previously known from the Plateau Limestone.

The ammonites include *Xenaspis carbonaria*, Waagen, an evolute discoidal form which has been previously recorded from the Permian of the Salt Range, and from the Chitichun region of Tibet. Another genus is *Nannites*, of which two species have been found. One of these is a form allied to *N. hindostanus*, Diener, and to *N. herberti*, Diener, both from the *Otoceras* beds of Spiti. The other species of *Nannites* shows certain distinctions from the former as well as from *N. bittneri*, *N. fugax* and *N. spurium* described by Mojsisovics from the Trias of the Mediterranean region. The form most commonly met with at Na Hkyam belongs to a new genus of the *Hungaritidae*.

Among the gastropods the dominant genera are *Pleurotomaria* and *Naticopsis*. The species of *Naticopsis* however are not identical with any of the Indian forms which have so far been described. A single species of *Holopella* is recorded. The genus *Neritomopsis* is represented by more than one form, and there are a number of not very well preserved specimens which are referred to *Murchisonia*. An interesting record is that of a single specimen belonging to the genus *Platystoma* Conrad. In addition to these there are a number

of other specimens which are probably to be referred to the *Neritopsidae*, but of which the affinities are not quite clear. Finally, Dr. Sahni notes that of all the gastropods recorded from these beds the genus *Pleurotomaria* is the most prolific alike in number of individuals and of species.

A number of lamellibranchs have also been noted. Forms belonging to *Schizodus* are the most common, but the genera *Aviculopecten, Lucina ?* and *Pecten* are also represented.

The evidence as regards the age of the beds is somewhat conflicting. The species *Xenaspis carbonaria* found in the Na Hkyam beds has been recorded from the Upper Productus Limestone of the Salt Range and would therefore indicate a Permian horizon. The genus *Schizodus*, though not confined to it, occurs very profusely in the Permian. *Holopella trimorpha* from the Upper Productus Limestone of the Salt Range and the *Holopella* found at Na Hkyam are very similar. On the other hand the genus *Nannites* has not been recorded from rocks older than the *Otoceras beds* (=Lower Trias).

Southern Shan States.

93. Dr. Coggin Brown made a traverse from Taunggyi, the capital of the Federated Shan States, to the east along the main route which leads to south-western Yunnan and Siam, as far as Wan Pong, a distance of 70 miles (sheets 93 H/1, 5 and 6).

The Plateau Limestones, which are mentioned in last year's General Report as extending for at least 20 miles to the east of Taunggyi, have now been found to reach to mile 28·3, where they finish at the crest of the ridge between the two Shan States of Hopong and Möng Pawn. Both divisions of this formation are represented, the lower of grey brecciated dolomites, sometimes friable enough to be kicked to powder; oftener, harder greyish-white, recemented material with a deceptive sandy appearance and occasionally banded with pink. In the upper division are thin-bedded, concretionary-tabular bryozoan limestone with interbedded marly and shaley layers. The latter rocks are very fossiliferous and contain abundant bryozoa, brachiopoda and corals. From them in 1900 Middlemiss obtained a few fossils which enabled Diener to decide their Anthracolithic character and to correlate them on the same level as those of the Middle and Upper Productus Limestone of the Salt Range[1].

[1] *Pal. Ind.*, N. S., Vol. III, Mem. No. 4, pp. 61-67, (1911).

Of all the Anthracolithic Burmese faunas this was, according to Diener, the poorest, while its materials as regards their states of preservation were less satisfactory than any other. The collections made during the present season will probably end this reproach and when they are studied lead to considerable extension of our knowledge of the fauna of this period. The most important fossiliferous localities are situated near miles 23-7 and 24-1 and 28-3, the brachiopods from the latter including *Productus* sp. and *Lyttonia* sp.

The only other occurrence of fossiliferous rocks of this age is between miles 36-5 and 37-2, where similar limestones and calcareous shales occur. They form a low cliff on the west bank of the Pawn River overlooking the Möng Pawn plain and possess a low easterly dip.

Between miles 28-3 and the Mong Pawn plain the ground is occupied by a series of crumpled green and purple mudstones, splintery greenish-grey shales and bleached sandy slates. No fossils have been found in these rocks, but it is believed they belong to one of the older Palæozoic systems. Around Möng Pawn there are thick deposits of late Tertiary clays, sand rock and pebble beds.

The Loi Samhpu range to the east of Möng Pawn is, on its western slopes, composed of light-coloured sandstones alternating with sandy shales. More massive varieties occur between miles 45 and 45-5 where they have a high easterly dip. Near Kyawkmoi, between miles 47-3 and 47-4, soft fawn and pink sandy mudstones with harder sandstones and alternating bands of purple mudstones are seen. The dip appears to be both to the east and west and the whole series has so far proved unfossiliferous.

At mile 49-7 from Taunggyi, the road crosses the summit of the Loi Samhpu through a pass where the whole lithological character of the country changes, and hard, slatey, grey limestones dip to the east at 45°. Similar limestones, with the same easterly dip, are found down the eastern flank to the 52nd mile, where they are followed by purple shales, which in their turn are replaced by limestones again. It is to be noted that these limestones bear no resemblance to any of the types of the Pleateau formation and that they are probably older. Similar alterations continue to Loi-lem at mile 58, though on the whole, on the lower eastern flanks, the slatey rocks predominate.

Loi-lem lies at an elevation of 4,200 feet in the south-west corner of the Loi Hka State. To the west rises the steep north and south trending ridge, a section across which has just been described, and which contains peaks rising to over 6,500 above sea level. To the north is the long narrow valley of the Nam Pawn, while to the east and south the drainage probably finds its way into the Nam Teng. The actual watershed is ill defined owing to underground circulation and the presence of numerous cauldron valleys and potholes. Between seventy and eighty of these are shown on the one-inch map within a radius of three miles to the north-east and south-west of Loi-lem and many smaller ones exist in addition.

About miles 58-5 and 58-7 to the east of Loi-lem, weathered outcrops of pale brown and pale purple mudstones occur which contain fragmentary organic remains. The only fossil which has been identified from these beds is a doubtful specimen of the Silurian coral *Palaeocyclus*. They are followed by limestones- very hard, fine-grained, compact rocks of greyish tints, often mottled with shades of red and purple, which give rise on weathering to a characteristic, large scale, cellular or polygonal-patterned surface. The prevailing dip of these rocks, well exposed between miles 59-3 and-4 and at 60-2, is high to the west.

The graptolite beds of Panghkawkwo follow the limestones to about 60-3¼, where they are replaced by the underlying purple slates. The former are white or greyish-white, perfectly fissile shales or mudstones with a very fine-grained matrix. Rarely they develop a brown or purple tint and become arenaceous. They are severely crushed in places, but the strike may be taken as N.15°E.—S.15°W. and the dip westerly at 65°. Miss Elles, through the good offices of Dr. Cowper Reed, has provisionally determined the graptolites as *Climacograptus* sp. and *Monograptus sedgwicki* (or *priodon*); at the same time two horizons or zones appear to be represented and further research is necessary before the question is finally settled. As far as can be stated at present the bed is not lower than Upper Valentian, while it may be higher Salopian.

The junction between the graptolite beds and the purple slates is concealed, but the latter extend from a point between miles 60-3 and 60-4 to 60-5 as dark purple mudstones, often nodular, generally bleached near the surface and containing crushed fragmentary fossils and small crinoid ossicles. Beyond them to mile 60-6, where limestones commence again, white sandy shales with alternations of

dark grey varieties are the only rocks visible. From the purple slates Dr. Cowper Reed has identified:—

Pliomera (Encrinurella) insangensis Reed.
Caryocrinus ? sp.
Hyolithes ? sp.

These fossils point to an Upper Naungkangyi Age. Alterations of limestones of the types already described, with shales and mudstones, continue to the 68th mile: at 68-1 hard, cleaved sandstones are found, while at 68-3 are softer varieties.

The older Palæozoic rocks appear to end near Wan Pong, for the Plateau Limestones again appear a little further to the east.

94. During the field-season 1930-31, Mr. V. P. Sondhi was deputed for survey work in the Southern Shan States. He completed sheets 93 D/9 and D/13, a portion of which was mapped by Dr. Coggin Brown,[1] and surveyed parts of sheets 93 H/1 and H/2. The following formations were met with:—

Alluvium, travertine deposits, and residual deposits	Recent to Sub-recent.
High-level pebble deposits of the Taunggyi foot hills	Pleistocene ?
Red beds	Cretaceous ?
Loi-an series	Jurassic.
Upper Plateau Limestone	Permo-Carboniferous.
Lower Plateau Limestone	Devonian.
Pindaya beds	Ordovician-Silurian
Orthoceras beds	Ditto.
Mawson series	Ordovician.

There is very little true river-borne alluvium in the area examined, the only insignificant patch being along the Toklet chaung, a tributary of the Panlaung river, which drains the western ranges of the Shan Plateau in sheet 93 D/9. Even this flat owes its origin, to a large extent, to travertine. The *Recent deposits* of the Yawnghwe and the Kunlon valleys in sheet 93 D/13, and those of the Hopong valley in 93 H/1, were apparently deposited under lacustrine conditions.

The elevated ground at the foot of the Taunggyi hills, in the south-west corner of sheet D/13, is built of clays and sands, with interbedded layers of pebbles, considered to be of lacustrine origin. uplifted to their present level in *Sub-recent* or *Pleistocene* times.

[1] See General Report for 1930, p. 89. *Rec. Geol. Surv. Ind.*, LXV, (1931).

The *Red beds* and the *Loi-an series* are enfolded in the Plateau Limestone and are confined to the western portion of sheet 93 D/9. Lithologically and structurally they are the northward continuations of the exposures mapped by Dr. Cotter and Mr. Walker in the southern adjoining sheet D/10 in 1922, in connection with the investigation of the Loi-an coalfield.[1]

In sheet D/9 the Legaung ridge is built up of the Loi-an series, with a narrow band of Plateau Limestone running along its top. Coarse quartzitic sandstones with high convergent dips form the bulk of the formation, with intercalations of mudstone and shale containing irregular seams of coal, from which a few fossil plants were collected. At one place a strong bed of argillaceous fossiliferous limestone was met in which *Alectryonia* sp. and crinoid stems are abundantly present. Dr. Cotter obtained Jurassic plant fossils from this series at Loi-an.

On either side the Legaung ridge is flanked by low dipping Red Beds, and north of Singu (20° 51′ : 96° 30′) this formation covers practically the whole of the Panlaung valley, where, west of the river, it is intruded by porphyry and dolerite. No fossils were obtained by Mr. Sondhi, but Dr. Fox, in 1929, collected two Cretaceous cephalopods from these beds at Kalaw.[2]

The *Plateau Limestone* is by far the most widespread rock formation of the area examined. The Lower Plateau Limestone is a dolomitised and highly crushed rock covering extensive tracts of the country. The Upper Plateau Limestone is fossiliferous and is usually exposed in relatively small outcrops confined, in sheets D/9 and D/13, to the immediate neighbourhood of the older Palæozoic rocks. East of Taunggyi, in the Hopong-Htamsang section, the limestone frequently contains beds and partings of shale. Foraminifera, corals, bryozoa and brachiopods are common in these beds and at least eleven genera of brachiopods have been provisionally determined.

The older Palæozoic rocks of sheets D/9 and D/13 were grouped by Dr. Coggin Brown into (1) the Pindaya beds, (2) the Orthoceras beds and the Mawsön series.[3] Mr. Sondhi completed the mapping of the *Pindaya beds* and discovered a rich assemblage of graptolites in the shales bordering the western flank of the inlier. *Diplograptus*

[1]Report on the Coal-field of Loi-an (confidential), by Dr. G. de P. Cotter, (1922).
[2] *Rec. Geol. Surv. Ind.*, LXIII, pp. 182-187, (1930).
[3] *Rec. Geol. Surv. Ind.*, LXIII, pp. 89, 90, (1930).

(particularly *Orthograptus*) is the most common genus, with a fair proportion of *Climacograptus* and *Monograptus*. All the genera are represented by a number of species and the assemblage is tentatively regarded as Lower Silurian. No branched Ordovician forms were found.

East of Alechaung (21° 0′ : 96° 33′ 30″), these rocks are interbedded with rhyolite.

On the eastern flank of the inlier Dr. Coggin Brown obtained a fossil fauna that he tentatively regarded as of Naungkangyi age. This view is confirmed by Mr. Sondhi, who made a further collection from the locality. Rocks resembling these mudstones were met on the top of the Taunggyi ridge and to the north of Hopong. They also form part of the Taunggyi range between the town itself and the Yawnghwe valley. Fossils collected from these rocks include cystideans, bryozoa, trilobites and brachiopods. Several specimens of *Orthis* bear a close resemblance to those obtained from the Naungkangyi series of the Northern Shan States.

The *Orthoceras beds* mapped to the north-east of Pindaya (Pangtara) contain a greater proportion of shales than are found in the type locality further east. Specimens of *Orthoceras* sp. occur abundantly in those beds, and Mr. Sondhi discovered graptolite shales near Kyawktap (20° 52′ : 46° 30′) wherein *Diplograptus* sp. and *Monograptus* sp. are conspicuous.

The *Mawsön series* mapped and described by Dr. Coggin Brown in the neighbourhood of Mawsön (20° 57′ : 96° 46′ 30″) was found to build up the whole of the Mawsön upland, as far longitude 96° 55′, where it ends in steep cliffs overlooking the alluvial plain to the east. The few fossils collected by Dr. Coggin Brown were, in the opinion of Dr. Cowper Reed, sufficient to stamp the rocks as Ordovician. Mr. Sondhi collected a few more fossils from here, and jointly with Dr. Coggin Brown discovered a new fossil locality in a railway cutting east of Heho.

The low elevated ground separating the Kunlon and Yawnghwe valleys in the eastern portion of sheet 93 D/13, is composed mostly of mudstones and limestones, somewhat different in lithology from any already mentioned. A few fossils, including well-preserved specimens of *Phacops* sp. and *Orthis* sp., were collected from them and it is hoped when the examination of the material is completed to establish their stratigraphical relations to the other formations.

Mr. Sondhi made a long traverse east of Taunggyi and collected Permo-Carboniferous fossils from several localities between Hopong

and Möngpawn (38th mile). East of Loi lem (58th mile) he discovered two new graptolite beds in addition to the one found by Dr. Coggin Brown, and near Wan Poong (69th mile) he reports the occurrence of another Permo-Carboniferous fossil locality.

Lower Chindwin and Shwebo districts.

95. Mr. B. B. Gupta continued the systematic survey of parts of the Lower Chindwin and Shwebo districts, working on sheets 84 N/11 N/12 and N/15. The northern half of sheet 84 N/11, east of the Mu River, was mapped by Mr. Sondhi in field season 1929-30. The southern portion of the same region proved to be entirely covered by alluvium. To the west of the Mu river a narrow alluvial belt is succeeded by a zone of plateau deposits gravels and red earth—which in its turn gives place to a fringe of Irrawaddians on the edge of the sheet.

Sheet N/12 is covered by the same formations, the Irrawaddians being best developed in the south-east corner, where they consist of buff and grey sandstones, whitish calcareous sandstones with intercalations of hard nodules, and bedded argillaceous sandstones, all of which weather into cappings of reddish and white sands. Selenite was found on a hill 1¼ mile N. E. of Gywebon (22° 4′ 95° 41′) and casts of *Batissa* and fossil wood at various places. An asymmetrical anticlinal fold occurs to the east of Tabayingwe (22° 3′ : 95° 40′).

The northern portion of sheet 84 N/15 was mapped by Mr. Sondhi in season 1929-30, who discovered a narrow band of metamorphic rocks near Thayetkon. on the western bank of the Irrawaddy (22° 23′ : 95° 58′). Mr. Gupta has followed the boundaries of this and has proved its continuation across the sheet, to the south, parallel to the Irrawaddy. Near Hmyaw-u kyaung (22° 21′ : 95° 59′) its outcrop is about a mile in width, narrowing both to the north and south in the direction of the strike. The metamorphic rocks themselves consist of hornblende-, mica-, and quartz-schists, granites, epidiorites and crystalline limestones. They are provisionally referred to the Mogok series. The remainder of the sheet is occupied by alluvium, plateau deposits and Irrawaddian rocks of the usual types.

Rangoon.

96. Mr. Leicester completed the geological survey of Rangoon and neighbourhood in connection with his work on the underground water supply of the city mentioned on page 74 under the heading of 'Water'. He produced a geological map of Rangoon and the country up to 16

miles to the north, on a scale of 2 inches to the mile, and seven horizontal sections across selected areas of the city.

The stratigraphical sequence worked out by Mr. Leicester may be outlined as follows :

Newer Alluvium .	Silt and clay (Top R. L. 10 to 15)
Upper Delta Alluvium	Sands. Gravels E. (R. L. —30 to —60).
Innesian .	Erosion terrace II (Top R. L. 50).
Windermerean	Erosion terrace I (Top R. L. 100).
Lower Delta Alluvium	Red earth and clay. Sand. Gravel D. (R. L. —120 near river; R. L. —40 to 50 inland) Inter-gravel sands. Gravel C. (R. L. —150) Inter-gravel sands. Gravel B . (R. L. —200). Gravel B. (R. L. - 250) Inter-gravel sands. Gravel A. (R. L. - 350).
Unconformity.	
Irrawaddian series.	
Pegu series.	

N. B.—The figures in brackets refer to levels reduced to the Survey datum level which is Mean Sea Level at Amherst.

Mr. Leicester describes exposures in Rangoon and the geological structure as interpreted from 147 strata logs, numerous borings along the river front and particulars of over 400 tube-wells sunk in the area, as well as from the surface features. He attempts a correlation of the gravels with the oscillations of land and sea-level. In Mr. Leicester's opinion the available evidence goes to show that, in agreement with recent oceanographic research in the Indian Ocean, there have been oscillations of sea-level which may eventually be correlated with the world-wide oscillations of level that were experienced during the Glacial Periods. Certain phenomena may be accounted for by the rising and warping of the supposed Rangoon anticline; but in Mr. Leicester's opinion the rising tendency of the geanticlines of the Indo-Malayan mountain arc must persist and the view that these geanticlines have periodically reversed their tendency to rise in favour of subsidence is untenable, and the explanation of the phenomena must lie to a great extent in fluctuations of sea-level.

Assuming that the gravels were deposited at places of low sea-level and consequent shallow estuarine conditions, Mr. Leicester suggests that the terraces recently studied by Mr. T. O. Morris of

the Indo-Burma Petroleum Company, in the central Irrawaddy valley, may represent the corresponding successive phases of high sea-level, the height attained diminishing with successive oscillations.

Central Provinces Party.

97. During the 1930-31 field season the Central Provinces Party consisted of Mr. H. Crookshank (in charge), Mr. W. D. West, Dr. S. K. Chatterjee and Sub-Assistant D. Bhattacharji.

Hoshangabad district.

98. During this field season Mr. Crookshank continued his survey of the northern part of the Satpura Range in the Hoshangabad and Chhindwara districts, his original work lying in the Hoshangabad district in sheets 55 F/7, 10, 11, 14 and 15, and 55 J/3.

This work almost completes the survey of the northern part of the Satpura Range, and Mr. Crookshank now propounds the following as the succession of formations in this tract:--

Alluvium.

Deccan trap flows and intrusions.

Lameta.

Gondwana .	Upper .	Jabalpur .	Jabalpur stage. Chaugan stage.
		Mahadeva .	Bagra. Denwa. Pachmarhi.
	Lower .	Bijori. Motur. Barakar. Talchir.	

Archæan.

As Mr. Crookshank has now incorporated the results of his work during the past few years in a memoir on the 'Northern Slope of the Satpura' offered for publication, it is unnecessary to refer to this season's work in detail. Reference may be made, however, to a few salient points. Along the northern edge of the Satpuras, where they meet the Narbada alluvial plain, there is a strip affected by a system of post-Deccan trap faulting with a general parallelism to the edge of the Satpuras, *i.e.*, E. N. E. As a result of this faulting, Deccan trap flows are found both beneath the alluvium at its southern edge and resting on various older formations, Archæan and Gondwana, up to heights that suggest that the total downthrow to the N. N. W. may amount to as much as 1,000 feet. The intrusive phase of the Deccan trap, developed so prominently in the country immediately to the south of the Pachmarhi plateau,

rapidly loses its importance in the country to the west of the Denwa river, the only noteworthy occurrence being a string of lenticular dykes along a great fault stretching N. N. W. from near Chandkia (22° 20′ : 77° 14′) near the Hoshangabad-Betul border to near Golandoh on the edge of the Narbada plain. This fault has a downthrow to the west and brings in the Budhimai area (22° 22′: 77° 32′) a great spread of Jabalpur beds, which are seen to overlap unconformably lower members of the Gondwana system from Bagra down to Bijori. Mr. Crookshank has carried his mapping as far west as Lokurtalai (22° 21′ : 77° 26′) on the Morund river and considers that he has proved beyond a doubt that the Lokurtalai coalfield is of Jabalpur age. He is confirmed in his mapping of the tract west of the fault referred to above by the discovery of fossil plants in black shales associated with the coal measures of Lokurtalai. He mentions *Ptilophyllum acutifolium*, *Araucarites cutchensis*, and some other doubtfully determined forms. In other parts of the Jabalpur tract *Dictyozamites* and *Tæniopteris* have been found, suggesting that these rocks belong to the Chaugan stage of the Jabalpur series.

Nagpur district.

99. From February to April, 1931, Mr. W. D. West continued the mapping of the Sausar series in sheet 55 O/6, and almost completed that portion of the sheet which falls in the Nagpur district. In the main his work was a continuation of that of previous field seasons. The two main belts of calc-granulite and calcitic marble in the west central portion of the sheet, the one running through Bothia (21° 33′ : 79° 21′) and Khapa (21° 36′ : 79° 18′), and the other just south of Kadbikhera (21° 37′ : 79° 18′) and Bakhari (21° 38′ : 79° 18′), when traced along the strike to the north-west meet just east of longitude 79° 15′. These two belts are regarded as anticlinoria, and the intervening portion as a synclinorium. There is evidently a gentle south-easterly pitch, as the synclinorium gradually dies out north-westwards, whilst the two anticlinoria meet around its north-west end. It is along the pitch of the synclinorium to the south-east, as it gradually opens out, that the Deolapar 'nappe' appears and gradually assumes a position of importance. This 'nappe,' to which reference was made in last year's General Report,[1] consists mainly of an impure facies of the Bichua stage of dolomitic marbles. As it dies out north-westwards its appearance is confined

[1] *Rec. Geol. Surv. Ind.*, LXV, p. 103, (1931).

to a few narrow outcrops, the tips of the synclinal folds of the 'nappe', before it finally vanishes into the air.

The mapping of the north west end of the southern belt of calc-granulites is much complicated by the intrusion of a great quantity of granite and pegmatite in an irregular and intricate manner. In places there is more igneous rock than metamorphic rock, while frequently the metamorphic rock has been replaced in whole or part by igneous material including vein quartz, making it very troublesome to map.

To the north of these rocks, north and north-west of Usripar (21° 37′ : 79° 20′) and Bakhari, there comes a large area of streaky biotite-gneisses and pegmatites, the whole of which are regarded as of igneous origin. The pegmatite and vein quartz magma which swamped this area must constitute nearly half the bulk of the rocks.

Further north again, the belt of rocks consisting of white dolomitic marbles (Bichua stage) and glassy microcline-quartzites (Chorbaoli stage), which has already been mapped east of the main road between Chhawara and Karwahi, has now been mapped west of the main road around Garra (21° 40′ : 79° 24′), Kursipar (21° 40′ : 79° 22′) and further west, and to the south up to the Dhoria *nala*. In the forest south of Garra these rocks occur as very flat anticlines and synclines. The marbles cap the higher ground, and the quartzites underlie them. Only occasionally is the Junewani stage of 'tabloid-schists' seen in between the quartzite and marble. To the west of Kursipar, the Chorbaoli, Junewani and Bichua stages all occur, in long narrow alternating outcrops. On their south side they come up against the extensive outcrop of orthogneisses referred to above. There is evidence to suggest that the junction between the two is a discordant one, which agrees with the conclusions reached in the previous season when dealing with the southern edge of this same belt to the east of the main road.

100. A late start followed by a serious accident[1] reduced Sub-Assistant D. S. Bhattacharji's field-season to little more than two months, whilst even this short period was interrupted by attacks of malaria. The part surveyed lies in sheet O/15 (the Tirora sheet)

Nagpur district.

[1] Mr. Bhattacharji fell down a pit dug as a trap for wild animals: the pit was covered at the surface. As a result of this fall Mr. Bhattacharji broke several bones, but I am glad to report that he has been able to resume work in the field late in the field season of 1931-32.

between the two hilly areas in the north-west and south-east corners thereof. Much of the solid geology is masked by alluvium, so that the isolated exposures mapped cannot be correlated with any degree of certainty. The exposures can, however, be classified into two series, the Sausar and the Sakoli, the distinctive characteristics of which have been described previously.[1] The Sausar series is represented by amphibolites and calc-granulites and the Sakoli series by chlorite-bearing schists, phyllites and quartzites. The associated rocks of the Sausar series in the area are dark-coloured. fine-grained biotite-gneisses, white acid gneisses, felspar-bearing schists, quartz veins, pegmatities and granites. The boundary between the two series runs N. E.-- S. W., approximately along a line jointing Khamari (79° 59′ : 21° 23′) and Panjra (79° 48′ : 21° 15′); to the north-west of this line lie rocks of the Sausar and to the south-east those of the Sakoli series.

101. During the field-season 1930-31 Dr. S. K. Chatterjee continued his survey of the Bhandara district and completed sheet 55 P/13 (the Sangarhi sheet) in addition to the central and eastern portions of sheet 64 C/4 (the Arjuni sheet). He obtained further confirmation of the sequence arrived at as a result of previous field-seasons' work.[2] In the Arjuni sheet the central plain forms the core of an anticlinorium whose axial plane strikes N.-S.; much of the solid geology is covered by alluvium, but the rocks that emerge to the east of longitude 80° 5′, consist of amphibolite or dolomitic marble and calciphyre in a 'country' of aplite and biotite-gneiss; chlorite-hornblende-epidote-schists are sometimes found in place of the amphibolite, and chlorite-tremolite-schists in place of dolomitic marble and illustrate regressive metamorphism.

Bhandara district.

The green quartzite that gives rise to the two parallel ridges through Mahalgaon (21° 1′ : 80° 2′) and Lawari (21° 3′ : 80° 1′) contains chrome-vanadium-muscovite and is thought to represent a facies of the Ramtek quartzite. Southwards, the Mahalgaon quartzite passes into hematite-chlorite-quartzite. On the east, the central plains gives place to a hilly tract bounded on its western margin by a low range of hills. These hills almost always consist of the tips of synclinoria formed of hematite-sericite-quartzite

[1] *Rec. Geol. Surv. Ind.*, LXI, p. 115; *op. cit.*, LXII, p. 132; *op. cit.*, LXIII, p. 116. See also *op. cit.*, LXV, p. 107, (1931).
[2] *Rec. Geol. Surv. Ind.*, LXV, p. 106, (1931).

infolded in phyllite and jaspilite. At the western foot of this hill-range amphibolite underlies the phyllites and jaspilite, so that if the amphibolite may be regarded as belonging to the Sitapar stage of the Sausar sequence, then the jaspilite and phyllite may be regarded as corresponding to the Sapchota stage, thus establishing a correlation between the hematite-sericite-quartzite and the Ramtek quartzite in accordance with the suggestion made in the last General Report [1]. The quartzite outcrops strike N. 15° E. at a slight angle to the general N.—S. strike of the area.

In the south-eastern part of the sheet three systems of faulting have been detected. These strike N.—S., N.N.W.—S.S.E. and N. 15° E.—S. 15° W., the first two being indicated by crushed quartz veins or microcline quartz pegmatite breccias, and the latter by comminuted quartzite.

About one mile west of Magarra (21° 3′ : 80° 12′) quartzite is overlain by phyllite and the latter by sheared felspathic quartz-conglomerate similar to that already described from near Kohka [2]. This conglomerate is a product of a set of thrust faults, conspicuous at its western margin; the primary one, which has a dip of from 30°-40°, has been traced for 2½ miles. A related fault strikes E. N. E.—W. S. W. at the south-eastern corner of the conglomerate outcrop. The cleavage planes of the conglomerate are not uniform and as a rule form an angle with the regional strike.

The formations described are succeeded by a great thickness of apparently unconformable 'greenstones,' which include epidiorite uralite-porphyry, and dacite tuffs containing epidote; the junction of these rocks with the underlying series is very distorted by shearing and faulting.

In the north-eastern portion of the sheet occurs a large exposure of muscovite-biotite-granite, whilst small outcrops of the same granite are scattered throughout the sheet. The granite is gently foliated, except near the periphery where the foliation is more intense, in a N.-S. direction and contains large felspar phenocrysts, which are aligned in the same direction and dip at low angles (5°-10°) to the east or west. A system of cross joints strikes E.—W. and contains epidote-quartz veins, often wavy and slickensided, whilst a later less conspicuous set of tension joints strikes N.-S. The boundary of the granite is often faulted, but its metamorphic effects

[1] *Loc. cit.*, p. 108.
[2] *Rec. Geol. Surv. Ind.*, LXIII, p. 115, (1930).

are nevertheless very evident. Veins of quartz-dumortierite-rock are associated with the granite at the knoll one mile W. 10° S. of Usekheda (21° 7′: 80° 14′).

The hillock about two miles north of Maldunga (21° 13′: 80° 7′) is formed of rutile-cordierite-kyanite-biotite-schist. It is surrounded on all sides by amphibolite into which coarse biotite-granite and pegmatites are intruded. The hill in the extreme south-east corner of the sheet is covered with lateritic iron ore assaying 46·6 per cent. iron and only 0·1 per cent. phosphorus.

The most interesting discovery in sheet 55 P/13 is that of a coarse biotite-granite about 4½ miles distant from the sillimanite occurrences at Pohra[1] and three miles from a tourmaline-damourite-schist band at Kaneri (20° 59′: 79° 51′). The latter is found in two small outcrops lying within the village and strikes N.-S.; it is associated with chlorite-muscovite schist and is intruded by numerous tourmaline-bearing and other quartz veins. In the immediate vicinity of the granite the chlorite-muscovite-schist has been converted into spotted schist, whilst further away large porphyroblasts of staurolite occur in otherwise normal rock.

The sheet is extensively covered by alluvium and the isolated exposures mapped consist for the most part of chlorite-muscovite-schist, phyllite, and sericite-quartzite in continuation of those found in the adjoining Sakoli sheet to the north. The general foliation strike is N.—S., whilst two prominent sets of fault-breccias composed of crushed quartz, strike N.—S. and N. N. W.—S. S. E., respectively.

Bands of dumortierite-topaz-kyanite-muscovite-schist on a N.-S. strike are found at Dighori (20° 53′: 79° 55′) and between Dahegaon (20° 48′: 79° 55′) and Murjhar (20° 50′: 79° 55′). At various places along the strike of these bands quartz-breccia was observed, whilst occasional small outcrops of granite were also found in their neighbourhood.

102. For the field season of 1930-31 Dr. Iyer, Sub-Assistant, was transferred from Burma to Madras, where he surveyed areas in sheets 57 P/1, 2, 3, 5 and 57 L/10, comprising parts of the Vellore, Walaja, Polur and Tiruvannamalai taluks of the North Arcot

Madras Presidency: North Arcot district.

[1] *Rec. Geol. Surv. Ind.*, LXII, p. 134.

district. During the course of his survey Dr. Iyer was able to establish the following succession of rocks in the area:

6. Alluvium.
5. Dolerite dykes and sills (Cuddapah).

Archaean:

4. Newer granite and gneisses.
3. Charnockite series.
2. Older gneisses.
1. Dharwars.

It was not possible to determine the relationship of the Dharwars to the Older gneisses owing to the lack of suitable exposures. The order shown above is that accepted by the Mysore geologists.

The *Dharwars* occur as thin bands (inclusions) in charnockite and consist of banded hematite quartzite (with magnetite) and hornblende-schists. Some of these occurrences are intruded by charnockite, leptynite and norite; they show complicated folding In the exposures in Kavuthy Malai and Vedappan Malai there are two varieties of hematite-quartzite, one a coarse-grained rock, and the other a finer-grained and banded type.

The *Older gneiss* consist of (*a*) highly foliated, banded, fissile and highly weathered gneiss, with pegmatite and quartz veins, and (*b*) biotite-gneiss, occasionally containing hornblende and garnet, with abundant intruded veins of pegmatite and quartz. The strike of the foliation varies between north and north east. Besides being well foliated these rocks are very highly jointed the jointing often giving the appearance of stratification.

The rocks of the *charnockite series* contribute to the prominent features of the area. They show considerable variation and differ somewhat from the rocks of the type localities of St. Thomas' Mount and Pallavaram. Kailasgarh Hill in the Javadi Hills, south west of Vellore (12° 55′ : 79° 8′), is composed of what Dr. Iyer terms biotite-charnockite, both coarse-grained and medium-grained varieties being seen. Flow structure in the form of basic *schlieren* is common, whilst banded and gneissic forms are also seen. Although these rocks have the general aspects of the rocks of the charnockite series, yet it is difficult to apply the term charnockite itself even to the acid forms, and hypersthene is not an invariable constituent; it is present occasionally, but a monoclinic pyroxene, slightly pleochroic, is much commoner. In some rocks both pyroxenes are absent, the ferro-magnesian constituent being represented by biotite

or hornblende. Although biotite and hornblende have not been mentioned in the charnockite of Pallavaram and St. Thomas' Mount, they are common in the related rocks of North Arcot, the quantity and the nature of the biotite giving a spotted, banded or foliated appearance to the rocks. Iron-ore, apatite, zircon, monazite, sphene, epidote, and rutile were noted as accessories in the charnockites in North Arcot: ilmenite forms the major part of the iron-ore. Contact-altered charnockites with sillimanite are also found as highly banded rocks, whilst the charnockites also show epidotisation on the tops of certain hills.

The garnetiferous leptynites of Pallavaram, as described by Sir Thomas Holland, occur at the margins of charnockite where it comes into contact with masses of norite. In North Arcot leptynites are found apparently as intrusions into the charnockites, independently of the presence of norite. One such occurrence is seen north-east of Kannamangalam (12° 5′ : 79° 9′). The leptynites of North Arcot vary from those of Pallavaram in texture and in mineral contents. They usually contain garnet, and sometimes biotite, whilst relict pyroxene is also present. The abnormal nature of the so-called charnockites and the presence of apparent intrusions of garnetiferous leptynite may be a result of regional metamorphism affecting the entire complex.

Intermediate members of the charnockites series appear in local bands or thin veins in the biotite-charnockites. Basic members of the series are more widely met with, occurring as irregular patches and inclusions, and as thin veins and thick dykes. One interesting exposure near Adaiyur (12° 16′ : 79° 3′) forms an ellipse, 2½ miles long in a N. E.–S. W. direction. The rock is a dark hornblende-augite-norite. This basic type contains hypersthene, augite, hornblende, iron ore and apatite, whilst labradorite forms an important constituent and quartz occasionally occurs.

Two types of pyroxenite and pyroxene-amphibolite are met with, namely (*a*) a type rich in hypersthene and (*b*) a type rich in hornblende. The latter type grades into amphibolite. Some olivine occurs in irregular grains in a pyroxene-amphibolite west of Chinnamalai (12° 25′ : 79° 13′).

In sheet 57 L/10, the north-west corner of the Javadi Hills is made up of pyroxene-geneisses closely allied to charnockites.

The *newer granites and gneisses* are intrusive into the charnockites. They consist of a pink gneiss in sheet 57 P/1 and a grey hornblende-

gneiss in 57 P/3 The pink gneisses are medium to coarse grained rocks composed of large crystals of felspar, quartz and biotite, with iron-ore and apatite as accessory minerals. The quartz and felspar occur in large crystals and form distinct bands.

Basic dykes occur in most of the charnockites and gneisses mapped during the season. They generally strike north south or east west, and are regarded as belonging to the *Cuddapah volcanic series*. They vary from hemicrystalline types to porphyritic normal dolerites and even to holocrystalline rocks. They also show a variation in composition from olivine dolerite to a dolerite containing a considerable amount of micro-pegmatite and residual quartz. Thin bands of altered basic rocks are also present in a few localities, they vary from epidiorites to rocks approximating to steatite rock.

Punjab and North-West Party.

103. During the field season of 1930-31, the Punjab and North-West Party consisted of Dr G. de P Cotter, Messrs. E R Gee W. D. West, J B. Auden, and Sub-Assistants H. M. Lahiri and P. N. Mukerjee Mr D N Wadia proceeded into the field late in the season and was given an independent charge in Kashmir.

Salt Range Punjab.

104. From November 1930 till March 1931, Mr. E R. Gee continued the re-survey of the Salt Range Punjab. The areas mapped included the southern part of the Jogi Tilla ridge and the adjoining northern end of the Chambal ridge (sheets 43 H/5 and H/6), the Karangal ridge and the adjoining southern end of Diljaba (sheets 43 H/1 and H/2), the northern edge of the Salt Range plateau between Khajurla (32° 45′ : 72° 59′) and Khokhar (32° 47′ : 72° 49′) (sheet 43 D/13) and the scarp slopes between the Sardahi (Sardi) gorge and the Kalra Wahan (sheets 43 D/10 and D/6). The latter area includes the Nilawan gorge.

According to Mr. Gee, the general stratigraphical sequence is similar to that in the adjoining areas of the eastern half of the Salt Range. (See General Reports for 1929[1] and 1930[2].)

The *Salt Marl series* is exposed within the southern part of the Jogi Tilla ridge in the vicinity of Nara (32° 48′ : 73° 24′) and crops out again in the northern end of the Chambal area. In these areas, only the upper part of the series, including red marl overlain by massive gypsum and dolomite, is observed. Similar outcrops of

[1] *Rec. Geol. Surv. Ind.*, LXIII, pp. 132 138, (1930).
[2] *Op. cit.*, LXV, pp. 114-118, (1931).

the topmost portion of the series are again exposed in the south western slopes of the Karangal ridge. In the basal scarp slopes to the west, however, between the Sardahi gorge and the Kalra Wahan, and within the numerous gorges which intersect the scarp, much wider and thicker outcrops occur. These exposures include the Red Salt Marl (with rocksalt) capped by massive gypsum, dolomite, and Khewra trap, and underlain by thick dull red gypseous marl.

The overlying *Purple Sandstone series* is usually well represented and varies from 200 to 300 feet thick. It includes the typical maroon shales and flags at the base followed by massive maroon and buff sandstones above; at Jogi Tilla, these basal sandstones are conglomeratic.

The *Cambrian beds*—including the Neobolus Shale and Magnesian Sandstone strata—which overlie the Purple Sandstones, continue throughout the eastern areas, though west of the Sardahi gorge the Magnesian Sandstone diminishes in thickness and eventually dies out in the vicinity of the Nilawan gorge.

The dark red shales and flags of the *Salt Pseudomorph beds*, are exposed in the Jogi Tilla area. They are absent in Chambal, possibly as a result of thrusting, but crop out again in Karangal and Diljaba. In the more western tracts they are absent altogether.

The *Speckled Sandstone series*, including the Talchir boulder-bed at the base, is not represented in the Jogi Tilla and Chambal ridges. It is present in the Karangal ridge sequence overlying the Salt Pseudomorph beds. The series is here relatively thin, but in the scarp slopes further west the Speckled Sandstones attain a very considerable thickness, as much as 650 feet in the Nilawan gorge. In these western tracts, they rest directly on the Magnesian Sandstone and still further west on the Neobolus Shale beds. Alternating thick red clays and gritty sandstones, overlain by dark purple and lavender clays, comprise the upper part of the series in the Sardahi Kalra Wahan areas. Bands of fine, white calcareous sandstone, interbedded within the topmost clays of the Nilawan gorge, include fragmentary fish-scales.

Within the Nilawan gorge, the *Productus Limestone* beds first make their appearance. They include massive, relatively soft, yellow-grey and greenish sandstones at the base, followed by calcareous sandstones and limestones above. These upper strata include numerous fossils—*Fusulina*, *Productus*, *Spirifer*, &c. The

series ranges up to 100 feet in thickness in this area, but thickens westwards towards the Kalra Wahan, where it forms prominent cliffs along the upper scarp slopes.

The *Nummulitic beds*, including the coal, shale, and pisolitic clay zones at the base, are of more widespread occurrence. Absent in parts of the Jogi Tilla and Chambal ridges, or represented only by the pisolitic clay beds, these strata are prominently exposed in the more western areas, where they form steep cliffs capping the scarp and crop out over wide areas of the plateau to the north. In the Nilawan-Kalra Wahan tract they attain a thickness, in places, of at least 400 feet. In the more eastern parts of the range, the pisolitic clay and coal and shale zones are closely associated, but in the Nilawan gorge and the scarp slopes further west, a zone of nummulitic shales, marls with numerous corals, echinoids, *Terebratulae*, &c., and thin limestones, varying up to 60 feet thick, intervene. The pisolitic clay zone also varies in character in the Nilawan gorge, where it includes fossils similar to those of the overlying marls. Sandstone bands, intercalated within the marls, include scales and teeth of fossil fish. The overlying nodular and semi-nodular Hill Limestones vary up to 300 feet thick.

On the Salt Range plateau between Khajurla and Khokhar, the Hill Limestones are overlain by from 50 to 80 feet of fine green shales and thin limestone with numerous foraminifera. These beds suggest certain of the Chharat strata of the Potwar area.

Siwalik beds overlie the Nummulitics to the north.

Throughout these areas, in the vicinity of the scarp, evidence of acute folding and in some cases of overthrusting is observed. In the Jogi Tilla and Chambal ridges, the strike conforms very closely with the topography. The general dip is north-westerly, often at a steep angle, though in the southern end of the Tilla area the strata swing round vertically to the south-east, with local evidence of shearing. In the case of the Karangal-Diljaba area, the principal tectonic feature is a complex overthrust, which runs along the lower western slopes of Karangal and continues as a more steeply inclined fold-fault, among the Siwaliks, to the north-western slopes of the Diljaba ridge.

Further west, between the Sardahi gorge and the Kalra Wahan, acute folding and some overthrusting, following an approximate east-west direction, and involving the Salt Marl, Purple Sandstone, Cambrian and Speckled Sandstone beds, are pronounced. These

structures are complicated by cross-anticlinal folds running approximately at right angles up the gorges that intersect the range in a north-south direction. The Nilawan gorge has been eroded along the axis of one of these sharp crushed anticlinals, along which there has also been local shearing and overfolding. In the higher parts of the scarp, and in the plateau areas to the north, the structure is relatively simple.

During the course of field work in early December 1929, Mr. Gee discovered certain fossils within arenaceous and dark red shaly bands intercalated in the steeply dipping dull red gypseous marl of the Salt Marl series. This gypseous marl underlies the bright red salt-bearing marl of the upper part of the sequence. These fossils were found in three sections of the Dandot (32° 39′ : 72° 58′) and Kheora (Khewra) (32° 39′ : 73° 0′) scarp areas and included a number of small foraminifera, and minute carbonised plant-fragments. The beds in which these fossils were discovered were regarded by Mr. Gee as definitely *in situ*, and forming a part of the Salt Marl series, and this opinion was upheld by Dr. Cotter, who visited the sections during February 1931.[1] During the present field-season (1930-31), Mr. Gee again found plant-fragments in certain shaly clay bands intercalated in the steeply dipping gypsum of the Nilawan, and in the topmost gypsum of the scarp-slopes north of Dhak coal depot (32° 35′ : 72° 30′).

The foraminifera, which in many cases are somewhat worn, due either to erosion or to corrosion by percolating saline solutions, were all very small forms, among which Mr. Gee recognised species of *Dictyoconoides*, *Siderolites* and megalospheric nummulites and assilines, resembling Lower Eocene types. The following species were determined by Col. L. M. Davies, to whom the specimens were shown :-

Dictyoconoides conditi.
,, *haemei.*
,, *newboldi*, var.
Siderolites miscella.
Nummulites cf. *mamilla.*

The first four of these specimens, which are definitely identifiable, have so far only been found in beds of Ranikot (Lower Eocene) age in the extreme north-western parts of India. The discovery

[1] *Proc. Eighteenth Ind. Sci. Congress.* (Pres. Address), Issued 8th July 1931. (Published by As. Soc. Beng., p. 300.)

of these fossils indicates a Ranikot or post-Ranikot age for the Salt Marl series, and appears to set at rest the long controversy about the age of the Salt Marl. We appear now to know that the age of this series is Tertiary and not Cambrian (see page 32)

In response to a request from Dr. F. R. C. Reed, Mr. P. N Mukerjee was instructed to make a collection of fossils from the Speckled Sandstones of the Salt Range, (sheet 43 D/11). Mr Mukerjee, however, in spite of a protracted search, could not find any new species, most of his specimens being examples of *Conularia.*

Attock district.

105. In the Attock district of the Punjab Dr Cotter mapped a portion of sheet 43D/1 (Potwar plateau area). This area proved to be entirely covered by Middle Siwalik rocks referable to the Dhok Pathan stage. He also found it necessary to revise some of the mapping done in previous seasons. It became clear, as mapping proceeded, that there had been some confusion between the conglomerate that lies at the base of the Upper Siwaliks and that which separates the Dhok Pathan from the Nagri stage. This confusion, which has affected A B. Wynne's original map,[1] has also had some influence on the map accompanying Mr. D. N. Wadia's memoir upon the country to the east,[2] and has led to similar confusion in the maps of the portion of the Potwar plateau that lies in Attock district, and was mapped in preceding seasons by Dr. Cotter and Mr. H. M. Lahiri. It became evident, as mapping proceeded, that the conglomerate horizon that in sheets 43 C/11, 43 C/12, and 43 C/8, and also the sheets to the west, had been regarded as the basal bed of the Upper Siwaliks, was in reality the basal bed of the Dhok Pathan stage. Dr. Cotter and Mr. Lahiri revised their maps accordingly.

A further revision of the area near Jand (sheet 43 C/3, and sheet 38 O/15) was made by Dr. Cotter and Mr. Lahiri. In sheet 38 O/15, in the preceding season, the mapping of the Kamlial outcrop had given rise to some discussion. The map was corrected by Dr. Cotter and Mr. Lahiri, and the Kamlial outcrop more accurately traced. In sheet 43 C/3, the south-west portion, which had been previously mapped by Mr. P. N. Mukerjee, was found to contain certain errors; these were corrected by Messrs. Lahiri and Mukerjee.

[1] *Rec. Geol. Sur. Ind.*, X, plate facing p. 107, (1877).
[2] *Mem. Geol. Sur. Ind.* LI, Pl. 11, (1928).

Mr. H. M. Lahiri, in addition to the above revision work, mapped portions of the Pindigheb and Talagang tahsils of Attock district, comprising sheet 43 C/1, part of sheet 38 P/13, and the Attock portion of sheet 43 D/2. In sheet 43 C/4, besides old and new alluvium, the geological formations met with were the Chinji stage the Nagri stage and the Dhok Pathan stage

The Chinjis are exposed as part of the western termination of the Dhulian dome (see *Mem. Geol. Sur. Ind.*, XL, p. 406) near Arazi Sarwai (33° 9′; 72° 11′). The Chinjis are overlain by about 5,300 feet of massive olive and grey sandstones with subordinate red and grey clays: these belong to the Nagri stage of the Middle Siwaliks. Scattered pebbles of igneous rock and fossil wood, generally altered in part to limonite, are of common occurrence.

Above the Nagris is a succession of white, brown or grey sandrock alternating with orange to brown sandy clays. These beds strike eastwards into the Dhok Pathan beds of the type area, and are lithologically similar to them, so as to leave no doubt of their Dhok Pathan age. Westwards, however, they pass laterally into an alternation of thick conglomerates, white sandstones, and orange clays, which cover the whole of sheet 38 O/16, and the adjacent parts of sheets 38 O/15, 38 O/11, 38 O/12 and 43 C/3. The conglomerates and their associated beds were regarded by A. B. Wynne, W. Waagen, and G. E. Pilgrim[1] as belonging to the Upper Siwaliks. These beds must now be placed in the Dhok Pathan stage, notwithstanding their conglomeratic character. Very few vertebrate fossils were collected from the area mapped, these were referable to *Hipparion* and the *Bovidae*.

The Soan geosyncline[2] continues westwards through the southern half of sheet 43 C/1 and 43 D/1 into sheets 38 O/16 and P/13. From east to west in sheet 43 C/1 the middle portion of the sheet is occupied by the westward continuation of the Dhulian dome, while in the north of the sheet a shallow syncline separates the Dhulian dome from the Kharpa anticlinal fold of sheet 43 C/3 to the north.

Sheet 43 D/2, which was mapped by Mr. H. M. Lahiri at the close of the season, is the westward continuation of the country shown

[1] In *Rec. Geol. Sur. Ind.*, XLIII, Pl. 26, Dr. Pilgrim places the conglomerates of Makhad in sheet 38 O/12 in the Boulder Conglomerate zone, but they are in reality, according to Mr. Lahiri, of Dhok Pathan age. See also *Rec. Geol. Sur. Ind.*, XL, p. 192, (1910).

[2] See *Rec. Geol. Sur. Ind.*, XLIII, Pl. 28, fig. 2, (1913), and *Mem. Geol. Sur. Ind.*, LI, p. 335, (1928).

in Plate 38 of Sir E. H. Pascoe's memoir (*Mem. Geol. Sur. Ind.*, XL, Pt. 3, (1920). This area, bounded on the south by the Salt Range, is occupied by rocks ranging from Laki (Hill) limestone to Middle Siwaliks. The Laki age of the limestone is indicated by the presence of *Nummulites atacicus* and *Assilina granulosa*. Above the limestone comes about 1,500 feet of massive olive green sandstone with subordinate purple to green sandy clays. These have been mapped as Kamlial in Sir E. H. Pascoe's map of the country to the east, but their position in the sequence, and their lithological appearance, render it more probable that they are the attenuated representatives of the Kamlial and Murree rocks taken together as a single unit. Fossil wood and ferruginous concretions are common in this zone. Above these Kamlial-Murree rocks are the red clays and soft subordinate sandstones of the Chinji stage, which is here about 2,000 feet thick. At the base of the Chinjis a pseudo-conglomerate with *Unio* was found. The Chinjis are succeeded by the Nagris, and these in turn by the Dhok Pathan stage, the lithology of which two stages is similar to that seen in sheet 43 C/1. The Nagris are here about 3,000 feet thick, as compared with the thickness of 5,300 feet near Dhulian. The thicknesses of these beds and of the Chinjis and Kamlial-Murree group shows that the whole sequence becomes attenuated in the south of the Potwar. The dips over the area mapped in sheet 43 D/2 are all northerly, and the beds form the southern limb of the great Soan geosyncline.

106. Mr. P. N. Mukerjee surveyed geologically during the field season the portion of sheet 43 D/1 left over by Dr. Cotter, and extended his map into the adjoining sheet 38 P/13. Besides alluvium, the area mapped was found to be entirely covered by Middle Siwalik rocks belonging to the Nagri and Dhok Pathan stages. The lithology of these was exactly similar to what has been already described for sheet 43 C/1; the rocks form the southern limb of the Soan geosyncline, the axis of which here trends to the south of west and at the same time opens out, so that the dips over the area mapped by Mr. Mukerjee are usually north-westerly.

107. During the later part of the field-season Dr. Cotter went to the Hazara district and continued the mapping of the country north of that surveyed by Mr. C. S. Middlemiss, whose map was published in Vol. XXVI of the *Memoirs of the Geological Survey of India.* In the course of this work Dr. Cotter mapped portions of sheets 43 B/15, 43 F/2

Hazara district.

and 43 F/3. The geological formations met with were granites and schists, exactly similar to those described by Mr. Middlemiss for the country to the south. Near Ahl (34° 53′ : 75° 9′) in sheet 43 F/2 the granite has been altered marginally by the action of sulphide vapours so as to be completely disintegrated, and on the road north of Ahl a yellow incrustation containing sulphur is seen upon the surface of the disintegrated granite.

108. Mr. Wadia took an opportunity of examining the Tanawal rocks of the Gandgarh range (34° 7′ : 72° 48′) on the Indus in western Hazara[1] before proceeding to Gilgit. This is a well-stratified series of purple, grey and white quartzites (metamorphosed sandstones) with quartz-schists and phyllites, associated with some massive quartzitic beds with peculiarly scored and grooved surfaces. The latter strata contain veins, layers and patches of coarsely crystallised dolomite. Near Mohut, along the strike of these quartzitic beds, there appear some hundreds of feet of what appears to be typical Infra-Trias limestone (dolomitic), indistinguishable from that of the type locality, namely Sirban near Abbotabad, as was noticed by Wynne.[2] The whole group constitutes a squeezed synclinal resting on finely schistose and phyllitic beds (? altered Attock slates). A much-crushed and deformed slate-conglomerate appears close to the junction-plane and suggests comparison with the Tanakki conglomerate; similar conglomerate beds, however, also appear in the body of the slate outcrop. The relations of this conglomerate to the Attock slate series of Hazara, and to the Tanawals, are highly obscure, a fact that was observed by Wynne and Middlemiss.

In close proximity to this outcrop, but on the opposite, west, side of the Indus, opposite Tarbela (34° 8′ : 72° 49′), there occurs a massive outcrop of the Infra-Trias limestone closely associated with a dark green, slaty, doleritic trap. The dolerite is both 'interbedded' with, and intrusive into, the limestones, and the phenomenon recalls the similar association of the Panjal trap and Agglomeratic Slate of Kaghan with thick belts of limestone taken to be of Infra-Trias age.

109. Mr. Wadia took the field in March to resume his mapping of the apical portion of the N. W. Himalayan syntaxial angle, namely the part that lies beyond the Great Himalayan Range. Before the condition of

Kashmir.

[1] Reported on by Wynne in 1879: See *Rec. Geol. Surv. Ind.*, XII, p. 122.
[2] *Loc. cit.*, p. 123.

the passes allowed his crossing this range, Mr. Wadia worked for two months in the Hundwara district of Kashmir (Sheets 13 J/3, J/2, J/6), joining up his previous seasons' work in Karnah and the mid-Kishenganga valley tracts with Bion's mapping of the older Palæozoic sedimentary basin of N. W. Kashmir. Middlemiss and Bion mapped the southern portions of the Hundwara district and in unpublished maps apply to a large tract the term 'unfossiliferous slate series.' This series underlies their Upper Silurian limestones and slate and forms the broad belt of mountains between Hundwara and the Kishenganga. Mr. Wadia is now able to prove definitely that this series is of either Cambrian or Cambro-Silurian age. This group consists of slates with thick interbedded limestones containing, at two or three localities, a fairly preserved fauna of *Agnostus*, *Microdiscus*, *Conocoryphe*, and several *Olenid* trilobites, together with *Lingulella*, *Obolus*, and a brachiopod that may prove to be *Discinolepis*. The lack of fossils in the lower portion of this thick system of deposits (aggregating several thousand feet), generally consisting of blue or green clays and dark sandy slates, may be due to a wide-spread obliteration of the contained fossils of which relics are still detectable, leaving unaffected only the indestructible *Annelid* tracks and pipes on the hard quartzose sandstones. A well-defined and manifestly conformable passage downwards from strata containing Silurian *Orthis* and *Strophomenids*, through these beds of probable Cambrian age, into the Dogra slate below, is seen in many sections to the north of the Kishenganga divide. The Silurians occupy a central ellipsoidal trough stretching from the head of the Tangdhar (34° 23′ : 73° 52′) valley to near Drugmul (34° 29′ : 74° 18′). It is warped by shallow folds and bisected by the broad alluvium-filled valley of the Pohru river. Mr. Wadia made a traverse across the northern limb of this Silurian basin from Trehgam (34° 31′ : 74° 10′), through the Pharkian pass (34° 37′ : 74° 5′) to the Purana and crystalline rocks of the Central Himalayan axis. This section descends through the obscurely fossiliferous Cambrians to the Dogra slate and thence to the graphitic and other crystalline schists belonging to the Salkhala series, which is developed in great force in the deep canon-like section of the Kishenganga, in its course from Halmat (34° 45′ : 74° 40′) on the east to Doarian (34° 44′ : 74° 1′) on the west. It is a notable fact that this synclinal depression has an E.-W. strike, whereas the normal Himalayan strike is N. W.—S.E. The plane of contact

of the Salkhalas with the markedly less metamorphosed Dogra slate is a thrust-fault. North of the Kishenganga the Salkhala series gradually becomes more crystalline, ultimately merging, according to Mr. Wadia, into the complex of granitoid gneiss that builds the crestal portion of the central range—the Great Himalayan Range of Burrard.

In the eastern part of the Shamsh Abari syncline (43 J/3) the Silurians are for the most part directly overlain unconformably by the Agglomeratic Slate and Panjal trap, the outcrops of the intervening Muth quartzite (Devonian) being here restricted to a few small discontinuous patches that have escaped the wide-spread overlap of the Carboniferous volcanic series. East of the Bangas glacial plains (34° 21′ : 74° 3′) the syncline widens considerably, due to a strong easterly pitch. The patch of Triassic limestone capping the traps on the Khunni Rawal peak, 13,845 feet (sheet 43 F/15—34° 15′ : 73° 57′) described in a previous report[1], is evidently a small outlier confined only to the western portion of the syncline.

In July Mr. Wadia proceeded to Gilgit and thence to Chilas (sheet 43 I), *via* Gurais (34° 37′ : 74° 51′) and the Dorikun or Burzil pass (34° 54′ : 75° 6′). This took him across the Central Himalayan axis and the rather ill-defined Ladakh range of this part. The only available maps of this region are the old ¼-inch sheets. North of the central range the country, physiographically as well as ethnographically, belongs to the Central Asian desert belt rather than to India. Stratigraphical interests change also as one leaves behind the Triassic belt of Gurais, the Nummulitics referred to later, and the Panjal volcanic belt of Pashwari (34° 45′ : 75° 1′) pressed against the southern flank of the Burzil pass. To the north of the pass for about 100 miles the rocks are biotite-gneisses and schists with some interbedded bands of marble and calciphyre, traversed by later intrusions of acid (hornblende-granite) and basic (dolerite) composition. It is a monotonous expanse of mountain rock-desert, devoid of soil or vegetation, and covered under a thick mantle of its own scree debris. The only variations from the monotony of the prevailing gneissic complex are provided by large and small areas, in intimate association with the gneiss, of graphitic schists and slates with interbedded coarsely crystallised marble. Mr. Wadia believes the gneiss to be in the main a para-gneiss, produced by the dynamic metamorphism of the Salkhala series. Into

[1] *Rec. Geol. Surv. India.*, LXII, p. 131, (1930).

this gneiss is intruded the 'Central Himalayan gneiss'. The whole gneissic complex, which must be regarded as a composite gneiss, has been subsequently invaded on a large scale by bathyliths, stocks and sills of a gabbroidal magma, the products of which have since been converted into amphibolite and epidiorite. These basic rocks give rise to long chains of mountains of bare, black, forbidding rock in Gilgit, Chilas and Skardo.

The Nanga Parbat massif (26,620ft.) rises as a solitary eminence from the gneissic terrain, presenting on the south face naked rock-cliffs 12,000 to 15,000 feet high; to the north the aspect is tame, though there is a descent almost in one stride of 22,500 feet in 11 miles to the Indus bed opposite Thalichi (35° 36′: 74° 40′). From field work around the flanks of this massif up to an altitude of about 15,000 feet, including an examination of the wide-spread moraines carrying debris from the higher parts, Mr. Wadia considers the geology of Nanga Parbat to be, broadly speaking, of great simplicity, for the mountain is composed almost entirely of finely schistose, streaky biotite-gneiss with interbedded calc-schists and marble. The whole assemblage is well stratified, with a clear though sinuous north-easterly foliation strike and a persistent dip to the north-west the apparent bedding of the gneiss, however, conceals an extreme amount of imbricated folding, shearing and thrust-faulting. The stocks and dykes of massive amphibolite and hornblende-schist, as well as of a white tourmaline-bearing granite, have also assumed stratiform shapes. In the Tarshing valley and further south-east, near Rattu (35° 8′: 74° 48′), the gneiss of Nanga Parbat gradually gives place to less metamorphosed Salkhalas, which stretch to the south as far as the Kishenganga. It must be pleasant to possess the philosophical temperament that enables one to regard this complexity as simple.

The tectonics of the region traversed to the north of the Great Himalayan Range are related to those of the syntaxial bend of the N. W. Himalaya, already studied in Hazara and Kaghan. The strike from Babusar (35° 9′: 74° 2′) to Gilgit (35° 58′: 74° 16′) is persistently N. E. to N. N. E. in direct continuation of the main regional strike of Hazara and Kaghan, while east of the Indus at Bunji (35° 22′: 74° 50′) the strike is, on the whole, N.-S., through Astor (35° 22′: 74° 50′). In the region from Astor northwards, the compression has been so great that the rocks on the two sides of the syntaxial bend have been forced into parallelism and the

knee-bend has been obliterated. But in the region just south-east of Nanga Parbat and Astor the eastern limb of the great syntaxial knee-bend of the mountains reveals itself clearly.

Twelve miles south-east of the Burzil pass Mr. Wadia discovered a very interesting occurrence of a small, much dissected trough of Eocene limestones, steeply faulted against the north-east end of the Triassic limestone cliffs of Gurais. The limestone is obscurely fossiliferous; but the lithology strongly resembles that of the dark grey, bituminous, foraminiferal limestones of Hazara and of the Attock Nummulitics. It is probably a westerly outlier of the Dras Nummulitics in Ladakh (34° 25′ : 75° 50′) brought to notice by Mr. Middlemiss in 1921. The limestone caps metamorphosed Salkhala schists, in the plications of which it is involved in small trough-folded, band-like, outliers.

The Simla hills.

110. During a period of some $3\frac{1}{2}$ months from the middle of March 1931, Mr. Auden continued his survey of the Krol belt between the Gambhar and Tons rivers, working in sheets 53 E/4, 53 F/1, 5, 6, 10.

Mr. Auden states that the most striking feature along this belt is the increase in metamorphism towards the south-east and east. The Blaini boulder bed becomes altered to a phyllite in which it is difficult to distinguish pebbles from matrix. The Infra-Krol shales pass to slates and then to pearly phyllites very similar to those found in the Chails. The Krol A limestones turn to calcareous slates and these to puckered slates. The shales in the supposed Tal beds turn locally to puckered phyllites with reconstructed mica parallel to the cleavage planes and rotated clastic quartz grains. Finally, Subathu shales may be indistinguishable from Blaini slates. There is no doubt about the correlation of the beds concerned, owing to the presence of such characteristic facies as the Blaini and the Krol B red shales. It is unquestionably true that the Chail and Jutogh rocks which lie to the north-east of the Krol belt are of a higher general grade of metamorphism than those rocks actually found in the Krol belt. Nevertheless, the frequent and puzzling convergence in lithological type and metamorphic grade of the rocks along the Krol belt with those of the Chails and Jutoghs must not be ignored. Mr. Auden remarks that it is impossible to regard metamorphic appearance as necessarily a function of age, and states that the order of succession can only be settled finally on a stratigraphical basis.

The prevalence of uninverted sequences is shown by the normal disposition of current bedding, with the false bedding curves facing concavely upwards. It has been objected that since, in laboratory experiments, there are exceptions to this rule, it is unsafe to draw conclusions from the disposition of the false bedding surfaces. Mr. Auden states that in areas where there is no question of inversion such as the Vindhyan shield, he has never once seen an exception Even if exceptions do occur, they must be so infrequent as not to invalidate conclusions drawn from a series of observations. In the Simla-Chakrata hills observations of current bedding have proved the following successions to be uninverted.-

(1) Simla slates in the Gambhar river.

(2) Jaunsars on the western cliffs above the Tons river.

(3) Supposed Tals in the synclinal basin south of Gunra peak.

The upper division of the supposed Tals, which shows some resemblance to the Jaunsars, cannot therefore be an inverted succession of Jaunsars in the middle limb of a recumbent fold. Neither can the underlying Jaunsars of Chandpur be inverted Tals.

The alternative explanation, that uninverted Infra-Krols and Jaunsars have been thrust over Krols, is discredited by the complete failure of the Blaini beds where they should be expected, since it would be impossible for Infra-Krols to be pushed over Krol limestones, and for Jaunsars to be pushed over both Infra-Krols and Krol limestones, without some Blaini being incorporated. Moreover, the two divisions of the supposed Tals, which by hypothesis might be Infra-Krols and Jaunsars, grade gradually into each other, without disturbance, and never show a trace of the Blaini boulder bed nor limestone.

It is necessary, therefore, until evidence to the contrary is obtained, to suppose that the succession is a normal sedimentary one, following after the Krol limestones. Erosion must have taken place before the deposition of these supposed Tal beds, to allow for their juxtaposition to Infra-Krols at the western edge of the basin.

The existence of two conspicuous arenaceous series such as the Jaunsars and the Tals, and the recurrence of carbonaceous beds throughout all the series in the district, are striking. The recurrence, also, of current-bedded and ripple-marked facies, testifies to the fact that during and since Simla slate times, the area in question has never been covered by deep water.

Mr. Auden states that the Jaunsar conglomerates and Blaini boulder beds are often crushed and sheared, so that the pebbles are elongated into ellipsoids with major axes parallel to an E. N E. — W S. W. direction. Similarly, the Jaunsar phyllites in the east of the area are sometimes thrown up in the same direction into small folds the size of large ripples. He comments on the similarity of these directions to that of the Aravalli range and suggests a period of local orogenic activity along this line at about the end of Carboniferous times. Such directions are not seen in the Krol and overlying series.

The Krol sandstone appears to be entirely missing east of Dadalu, and Krol A limestone follows directly on Infra-Krols, the passage from one to the other being seen by the loss of carbonaceous shales or slates and the entry of impure limestones The Krol D (chert-limestone and shale) section, which was so characteristic near Sainbar on account of the irregular folding of limestone bands in excess of shale, becomes less shaly eastwards. The result is that the three sections C, D and E begin to lose the individuality they possessed to the north-west. Further, folding is so tight and involved that it becomes impossible in the east to map these less individualised sections separately. In sheet 53 F/10. Krol C, D and E have been mapped as a single upper Krol limestone division It is proposed to unite the Infra-Krol, Krol sandstone and Krol limestone divisions into one series called the *Krol series.*

111. During the seven weeks available for work in the Himalaya during the hot season of 1932 Mr. West commenced the mapping of the Chakrata district, United Provinces, the northern part of the district being selected by reason of the close resemblance of its rocks to those of the Simla hills further west, which he had recently mapped.

Chakrata district.

In 1882 Mr. R. D. Oldham made a map of this district on the scale of one inch to one mile, and published a short paper thereon. [1] As a result of the work done in the hills this season, Mr. West has, however, had to introduce a good many changes.

The chief feature of the northern part of the district is the fine development of the Chail series. In this series an extra stage appears at the top, which is not seen in the Simla hills further west. The Chail series has thus to be divided into three stages, a lower stage of dark grey, schistose slates containing a bed of dark blue

[1] *Rec. Geol. Surv. Ind.*, XVI, p. 193, (1883).

limestone, which is usually banded and contorted, a middle stage consisting of pure quartzites and quartz-schists, and an upper stage of schistose grits, the grade of metamorphism of which has sometimes reached the biotite stage.

Structurally the most striking feature is the way the Chail series, with a low northerly dip, overlies various rocks that usually display a high dip and are often considerably folded. This feature was noticed by Mr. Oldham, who concluded that the Chail rocks, which he spoke of as Bawars, in spite of their higher grade of metamorphism, were younger than the rocks below them, which they overlay unconformably. This junction, which he took to be an unconformity, is really the Chail thrust, by which the Chail series have been brought to lie upon younger rocks, thus explaining the apparent anomaly of the greater metamorphism of the upper rocks.

A good deal of the Lower Chails, which contain limestone, Oldham took to be Deoban; while elsewhere he has mapped the Chail limestone with his Chakrata series. His Bawar series were what would now be called the Middle and Upper Chails.

The outcrop of the Chail series is not everywhere a straightforward succession. At Phanyar (30° 53′ : 77° 51′) the Lower Chails, with the Chail limestone, are seen resting on the Deoban limestone, from which they are separated by the Chail thrust. They are overlain by the lower part of the Middle Chails, which form the peak known as Thik. But the upper part of the Middle Chails is not seen, nor are the Upper Chails. Instead the Lower Chails with the Chail limestone, reappear, resting on the Middle Chails. The section from now onwards is a normal one, the Lower Chails being succeeded above by the full development of the Middle Chails, and the latter by the Upper Chails. Throughout there is a gentle north-easterly dip. It is clear that part of the Chail series is repeated by an overthrust. The line of this overthrust is most clearly seen a mile and a half north-west of Purtar (30° 55′ : 77° 55½′), where, by Kolyar, the Lower Chails with the Chail limestone near the base, are clearly seen resting on the white quartz-schists of the Middle Chails.

Below the main Chail overthrust there come either the Mandhali beds or the Deoban limestone. Detailed examination of these two formations leads to the conclusion that the Mandhali beds are but the upper part of the Deoban series. The Mandhali beds,

as concluded by Oldham, are essentially shallow water deposits; and, as there is a gradual transition from the Deoban below up into the Mandhali beds, they evidently represent the deposits formed during the shallowing of the Deoban sea. The highest Mandhali beds include a limestone and a rather sheared boulder bed very similar to the Blaini beds; and it seems likely that the upper Mandhalis are the equivalent of the Blaini beds in the Simla hills. If this correlation be correct, the Deoban limestone must be approximately of Carboniferous age, and cannot be the same as the Krol limestone, which is regarded as Upper Carboniferous to Permian in age, corresponding to the Infra-Trias of Hazara.

As mentioned above, the dip of the rocks below the Chail thrust is everywhere much greater than the dip of the Chail series above the thrust, though the strike and direction of dip are usually much the same in both. The general dip being to the N. N. E., in this direction higher and higher beds come in below the Chail thrust. Consequently it is in those valleys which have a N. E.—S. W. direction that the highest Mandhali beds are found, while on the spurs in between the Mandhali beds are either very thin or missing, in which case the Chail series rest directly on the Deoban limestone. These relationships are well seen in the upper part of the valley of the Dhara Gad (30° 51½′ : 77° 55′) by Hartar and Patouri, and also in the Tons valley by Tiuni (30° 57′ : 74° 51′).

Below the Deoban limestone comes the Jaunsar series, which, as re-defined by Pilgrim and West, is the equivalent of the middle and upper part of Oldham's Jaunsar system, or 'Chakrata series' as he originally called them when mapping this district. They have been mapped this season in two localities, in the Beshair Gad (30° 47¼′ : 77° 58′), and in the Gutu Gad (30° 48′ : 77° 54′). In these two valleys the Deoban limestone occurs both above and below the Jaunsar rocks. Although these two outcrops are on the same strike, they both end as they approach the higher ground which separates them. It seems probable that the Jaunsar beds have been brought up by a flat overturned anticline from below the Deoban. That they do not reach the high ground by Kharambe peak and Bathawa Tibba is due to the anticline closing upwards. In addition to the usual massive and sometimes false-bedded quartzites with slates, which are typical of the Jaunsar series in the Simla hills, there occur as well a few greenstones and chlorite-schists.

The Jutogh series is not represented in the Chakrata district, nor are there any acid intrusive rocks comparable with the Chor granite and its associated pegmatite dykes.

Rajputana Party.

112. During the field season 1930-31 the Rajputana Party consisted of Dr. A. M. Heron (in charge), Mr. A. L. Coulson, Dr. P. K. Ghosh, and Sub-assistant B. C. Gupta.

This season saw the conclusion of the geological survey of the crystalline area of Rajputana, which had been commenced by Dr. A. M. Heron in 1908. The only portions of Rajputana still awaiting survey are in the arid tracts of Marwar, Bikaner and Jaisalmer, of which adequate topographical maps are not available.

Jodhpur and Bikaner States.

113. Dr. A. M. Heron worked on the half inch to one mile sheets 160, 161, 162, 191, 192, 193, and 194, and on standard sheets, one inch to one mile, 117, 118, 119, 137, 138, 139, 140, 141, 142, 143, 163, 164, 165, 166, 167, 168, 195, 196, 197, 226 and 227, all of which are now completely surveyed. Politically this is comprised within Marwar (Jodhpur State), with a small adjoining portion of Bikaner State.

At the commencement of the season Dr. Heron examined the country to the north and west of the Sambhar Lake, where ridges of the Alwar quartzites mark the dying-out of the Delhi synclinorium as it disappears under the sandy alluvium. The base of the Delhi system is seen in the short ridge three miles east of Marot (27°6′ : 75°7′) mentioned by Hacket, [1] where grits with pebbles of felspar, pegmatite, quartz and quartzite, rest upon biotite-schists cut in all directions by reddish pink pegmatite. The foliation of the schists happens to be nearly parallel with the stratification of the grits, but there is no doubt about the reality of the unconformity, as part of the material of the grits is derived from the pegmatite veins in the schists.

There are five sets of quartzite ridges, of which the most easterly are composed chiefly of arkose and conglomerate, and the other three of vitreous coarsely crystalline quartzite.

The average strike is N. N. E.—S. S. W., veering locally to N.- S. or N. E.—S. W.; dips are generally to W. N.W. at angles of 60° to vertical.

[1] *Rec. Geol. Surv. Ind.*, XIV, pp. 297-8, (1881).

At the bases of the quartzite ridges traces of the upward succeeding formations are sometimes seen—mica-schists, impure limestones, calc-gneisses and epidiorites, intruded by tourmaline-pegmatite and dolerite; they may be correlated with the Ajabgarh series.

The next portion of the season was spent in visiting isolated and widely scattered outcrops of Aravalli slates and quartzites, of the Malani rhyolites and the associated (Idar, Jalor or Siwana) granites, and of the red, pebbly sandstones and cherty limestones, which have been correlated with the Upper Vindhyans of Central India.

The Aravalli exposures to the north-west of the range consist chiefly of sheared and shattered slates with thin, impure quartzites interbedded. The most northerly of these is a group of ruggedly peaked hills of quartzite south-west of Gopalpura (27° 45′ : 74° 16′), just inside the southern frontier of Bikaner. Both in strike and in dip they are very disturbed, but show no sign of igneous intrusion. Over a distance of about five miles they emerge at intervals from the alluvium, with an isolated outcrop seven miles to the south.

The next Aravallis to the south lie to the north-west and south-west of the salt lake of Didwana (27° 23′ : 74° 36′). They are vertical or show a high westerly dip, and have a N. N. E.-S. S. W. strike. Slates predominate, but a few quartzites and small veins of white quartz also occur.

Near Khatu (27° 7′ : 74° 21′) slates [1] underlie the Vindhyans and a ridge of quartzite stands out upon the plain to the east of the Vindhyan scarps.

From Degana town (26° 50′ : 74° 23′) an interrupted ridge of argillaceous quartzites and phyllites runs southwards for over eight miles. The former are indistinctly bedded and irregularly jointed, and much twisted in dip and strike. At Bagar (26° 42′ : 74° 16′), six miles to the west of this ridge, is a large quarry in brown chert-veined serpentine or serpentinous limestone, used locally for building-stone and for lime-burning. A mile to the west of this is a small outcrop of white quartzite blotched with purple iron-staining, and a similar but larger exposure appears on the same strike, six miles to the north-east.

Phyllites are associated with the wolfram-bearing granite [2] of Rewat, (26° 54′ : 74° 19′) near Degana Railway Junction, which

[1] *Rec. Geol. Surv. Ind.*, LXV, pt. 4, p. 472, (1932).
[2] *Rec. Geol. Surv. Ind.*, XLIV, p. 26, (1914); XLVII, pp. 26-7, (1916); LXVI, p. 82, (1932).

intrudes them, and also occur at several localities near the gneissic area of Harsor.

The gneiss of Harsor (26° 44′ : 74° 31′) forms a slightly raised tract eight miles long and three miles wide, with a possible extension for another six or seven miles to the south-west, under alluvium. At the south-west end the gneiss is fine-grained and very indistinctly foliated, with numerous veins and dykes of tourmaline-pegmatite; these do not extend as far east as the highest point of the outcrop. Passing to the north-east, towards Harsor, the gneiss becomes coarser, and shows foliation more clearly. To the north-east of Harsor, there are many veins of reddish pink aplite. The separate outcrop of gneiss at Mori, four miles south of Harsor, is still coarser and is more distinctly a gneissic granite, and not unlike the Erinpura granite. It is impossible to say definitely whether this Harsor and Mori gneiss is pre-Aravalli, or is an intrusive in the Aravallis; it might be, for instance, a case of the post-Delhi Erinpura granite.

The northernmost exposure of the Malani volcanic rocks is hill 1301, two miles west of Biramsar village (28° 2′ : 74° 48′) in Bikaner, close to the frontier with Jaipur State. This hill is composed of rhyolite tuffs, converted into rough grey slates, greatly crushed, and breaking into lenticular plates through shearing. They are vertical, and strike N. N. W.—S. S. E. Here and there are bunches of quartz stringers, with harder silicified patches in the tuffs around them. (See 'Copper', p. 43.)

The hill 1436 north of Randisar (27° 53′ : 74° 32′) in Bikaner, consists of black and pinkish brown massive rhyolites, in flows up to 50 feet in thickness. The general dip of the flows is 50° to 70° to east and north-east. At the south end of the hill columnar jointing is well developed, in columns two and three feet in diameter. The rocks are little weathered and almost glassy, phenocrysts of felspar being seen only on inspection of the freshly broken surfaces with a lens.

Fourteen miles to the S. S. E. is the group of rhyolite hills west of Lodsar (27° 42′ : 74° 37′) and Taonra (27° 38′ : 74° 37′) just within the Jodhpur frontier with Bikaner. The rhyolites are varying shades of reddish brown to black, with abundant small phenocrysts of pink felspar. At the western base of the most northerly hill are exposed pink unlaminated tuffs, blotched brown with iron, and near the crest of the same hill is a greenish tuff of coarser tex-

ture. At the north end of the middle hill (1,299) non-porphyritic rhyolites occur, but generally they are porphyritic.

Except for the tuffs, all the rocks have a distinct stratification, probably due to flow-structure, vertical or dipping eastwards at 70° or more; this causes them to weather like slates, in contrast to the thick massive flows of Randisar hill.

About three miles east of these hills is a small 'tor' of rounded masses of fine-grained, non-porphyritic and unfoliated granite. This is probably the Idar granite of Middlemiss[1] and the Jalor and Siwana granites of La Touche,[2] associated with the Malani rhyolites.

The similar, but larger 'tor' 1238, three miles east of Khuri (27° 50′ : 74° 47′), is probably the same rock.

The remainder of the Aravalli and granite exposures visited are in closer association with the Vindhyan sandstones east of Jodhpur City and are described in Dr. Heron's paper, 'The Vindhyans of Western Rajputana', published in the *Records of the Geological Survey of India*, Volume LXV, part 4.

The last half of Dr. Heron's season was spent on the north-western side of the great synclinorium of the Delhi system, where intrusion by the Erinpura granite and its derivatives reaches its maximum intensity, with consequent difficulty in recognising the different formations.

As is the case on the other, south-eastern side of the syncline a pre-Aravalli gneiss is present, extending along the edge of the synclinorium, though on this side we are unable to see its relations to the Aravallis. The Aravallis themselves are very little seen, and do not occur in the neighbourhood of the Delhi syncline, but only some ten miles or more away from it.

In field-season[3] 1922-23 the basement conglomerate of the Delhis was seen to rest unconformably upon the gneiss in the vicinity of Bar (26° 5′ : 74° 9′), but in this year's area igneous intrusion renders it impossible to decipher this.

The Raialo series is probably represented by the celebrated marble of Makrana, and along the same strike, by the marbles examined in the field-season 1922-23.[4]

In the south-west, at Sarangwa (25° 17′ : 73° 33′) is a mass of very similar marble, completely surrounded by Erinpura granite,

[1] *Mem. Geol. Surv. Ind.*, XLIV, pt. 1, pp. 117-126, (1923).
[2] *Op. cit.*, XXXV, pt. 1, pp. 24-25, (1911).
[3] *Rec. Geol. Surv. Ind.*, LVI, p. 56, (1924).
[4] *Ibid.*, p. 52.

which may represent an outlier of the same formation, originally resting upon the gneiss and now engulfed in the intrusive granite.

The Delhis are found to have here the same threefold division into 'biotite-schists', 'calc-schists', and 'calc gneiss and calciphyres,' using the field terms hitherto applied.

The Alwar series has apparently died out, and all these three divisions may be included in the Ajabgarh series.

The formations are affected by intrusion in their order of superposition. Along any given transverse section across the synclinorium, the 'biotite-schists' will be found to be more intruded than the 'calc-schists,' and they again more than the 'calc-gneisses'. This is in large measure due to their lithological composition, for the more biotitic, or the more schistose, a rock is, the more easily is it penetrated by granite or pegmatite, and, on the other hand, the more purely calcareous rocks are the more resistant. Also, *along* the synclinorium, the amount of intrusion increases as the great Erinpura--Abu batholith of granite is approached. Thus as one passes along the north-west flank of the synclinorium towards the south-west, *i.e.*, in the direction of the great batholith, the 'biotite-schists' at the base are the first to disappear in a welter of intrusives, followed further on by the 'calc-schists', while the 'calc-gneisses' retain their individuality to the furthest point to which they have been followed.

As well as intrusions of granite, aplite and pegmatite, the 'biotite-schists' and the 'calc-schists' carry large quantities of epidiorite and hornblende-schist, which may represent either basic lavas, or intrusive sills earlier in age than the Erinpura granite.

The general foliation and stratification dips of all formations are isoclinal, usually high, in an E. S. E. or S. E. direction, or vertical.

At the termination of the season Dr. Heron connected up his own work, and that of Mr. Auden (in the last field-season) and Dr. P. K. Ghosh, in Mewar and Marwar, with that of Mr. A. L. Coulson in Sirohi.

115. Dr. P. K. Ghosh worked in Marwar (Jodhpur State) during most of the field-season, on standard sheets C. I. and Raj. 116 117, and 118, and at the end of March proceeded to north Mewar (Udaipur State) to work on 200 and 201. All these sheets are now completely surveyed.

During January and February he accompanied the survey party of the Bombay—Sind Connection Railway across the Rann of Kachh

The former area was in westward continuation of Dr. Heron's work, and comprises the same sedimentary rocks of the Delhi system, with the basic igneous rocks (epidiorites), but Erinpura granite occupies by far the largest part of it.

Udaipur State (Mewar).

116. In north Mewar the rocks are predominantly mica-schists and gneisses belonging to the Aravalli system, with intrusive epidiorites and hornblende-schists.

117. Throughout the field-season Mr. B. C. Gupta worked in Mewar (Udaipur State), on standard sheets C. I. and Raj. 167, 168, 169 and 170, carrying the work into the adjoining sheets 141 and 142 on the west, thus linking up recent surveys in Mewar with those of Dr. Heron and Mr. Coulson in Ajmer-Merwara in the field-season 1923-24. All these sheets are now completely surveyed.

The area under review is almost entirely occupied by rocks of the Aravalli system, with several small outliers of the Raialos, and the great syncline of the Delhi system in the north-western corner of the area. The Aravalli system is represented principally oy phyllites and mica-schists, or by gneisses formed by the injection of granite material into the schists. The schists frequently bear garnet and staurolite, and gradually give place to a gneissic rock in the western and north-western regions. The transition types are irregularly banded gneisses, consisting of dark biotitic bands alternating with the lighter coloured injected aplitic or pegmatitic material. Further west it becomes more homogeneous, but still well foliated, with lines of pink felspars along the *folia*.

In close association with this gneiss have been mapped several masses of a granite not very different from the gneiss, the two grading into each other. Mr. Gupta suggests that the gneiss represents the product of contact and absorption, while the granite shows the unadulterated central core of the plutonic mass.

Besides these there are definitely later intrusive granites, epidiorites and other basic rocks.

The Raialos are represented by a narrow ridge of marble, coarsely crystalline and dolomitic, which forms the eastern end of an extensive outcrop mapped previously on the adjoining sheet to the west.

Sirohi State.

118. Mr. A. L. Coulson completed his survey of Sirohi State, Rajputana. As Mr. Coulson's memoir[1] on the geology of Sirohi has been submitted for publication, it is proposed to refer briefly in the present report to that

[1] *Mem. Geol. Surv. Ind.*, LXIII, pt. 1 (in the press).

portion of the State surveyed during the last field season. This lies on the old one-inch sheets of the Central India and Rajputana Survey Nos. 75 (45 $\frac{D}{1 \& 5}$), 76 (45 $\frac{D}{2 \& 6}$), 95 (45 $\frac{D}{9 \& 13}$) and 96 (15 $\frac{D}{10 \& 14}$), the new numbers of the sheets being in parenthesis.

The basement rocks belong to the Aravalli system and comprise mica-schists, phyllites, shales, crystalline limestones, quartzites, grits and conglomerates, with (?) contemporaneous tuffs and lavas. The oldest members of these found in the State occur near Sindret (sheet 95). The Sindret conglomerate contains large pebbles of quartz, quartzites, mica-schists, quartz-schists, etc., which are considered to be derived from some older members of the Aravallis which had suffered erosion before the laying down of the Sindret conglomerate. The conglomerate is associated with thin quartzites, ? contemporaneous basaltic and tuffaceous rocks, ferruginous shales and phyllites, etc.

It is considered that the post-Delhi Erinpura granite batholith forming the Abu *massif* was intruded at or near the junction between the Aravallis and the Delhis. The latter are now found to the east of Mount Abu, the Aravallis occurring to the west. Marginal faulting accompanied the intrusion of the granite.

Basic rocks intruding the Erinpura granite (but older than the Idar granite) are extremely abundant in the western plains. An interesting suite of igneous rocks was noted near Mundwara and Toa (sheet 95). These may be of the same age as the Kui and Chandrawati gabbros and those in the south-eastern corner of the State,[1] which have been tentatively classed with the basic rocks of the western plains, later than the Erinpura granite, but earlier than the Malani volcanics. The Mundwara rocks comprise picrites, dolerites, pyroxenites, basalts, olivine-gabbros and sodalite-syenites, the occurrence in Rajputana of the last named, and indeed in India, being rare.

The granite forming the Nandwar and Sunda hills in the extreme western part of the State has been correlated with the Idar granite (=Jalor or Siwana granites of La Touche) of Malani age. Its hypabyssal and volcanic representatives (the Malani rhyolites) have been studied in detail.

A few basic rocks were noted intruding the Idar granite or its volcanic representatives. These post-Malani basic rocks have been

[1] *Rec. Geol. Surv. Ind.*, LXIII, pp. 448-450, (1931).

correlated with the albitised dolerites found in the extreme south-western corner of the State.

Twelve analyses of igneous rocks occurring in Sirohi have been made by Mons. F. Raoult of Paris; these analyses will be published in Mr. Coulson's description of the geology of the State.

United Provinces, Mirzapur district; and Central India, Rewah State.

119. Mr. Auden spent the period from December 1930 to March 1931 in continuing his examination of the Vindhyan rocks along the Son valley in Mirzapur district and eastern Rewah, working in sheets 63 L/10, 14, 11, 15 and 63 P/2, 6, 3, 7. Subsequently he spent two days at Tirohan, near Karwi, on the northern side of the Vindhyan shield. The objects of his work were to investigate the nature of the boundary between the Lower and Upper Vindhyans, and to decide whether the so-called Lower Vindhyans should properly belong to the Vindhyan system.

Mr. Auden has continued the adoption of the term 'Semri series' in place of the prevalent term 'Lower Vindhyans'. He considers that there is no reason, in the area examined, to separate the Semri series from the Vindhyan system, but, on the contrary, that the abundant signs of shallow water and sub-aerial conditions, common both to the Semris and to the succeeding divisions are enough to warrant the inclusion of all the divisions in the one Vindhyan system. This he regards as mainly of fluvio-deltaic origin, interrupted by occasional marine incursions in Semri and Bhander times.

Mr. Auden lays stress upon the presence of glauconite in the Semris on both the north and south sides of the Vindhyan shield, and he considers this to be of correlative value. The Tirohan limestones are admittedly not exactly similar to their supposed equivalents in the Rohtas stage, but the presence of flaggy glauconitic beds below both the Rohtas and Tirohan limestones would appear indication enough of the general equivalence of the beds below the Kaimurs at Tirohan and along the Son valley. It may be objected that it is unsound to make use of the presence of a facies mineral such as glauconite for purposes of correlation. Mr. Auden remarks, however, that in a classification, such as that of the Vindhyan system, which cannot be isochronic but can only be lithological, the presence of a distinctive mineral should be of valid application, particularly when this is found to be confined to a characteristic group of rocks, limited in thickness, and showing constant relations with the beds above and below.

With regard to the Semri/Kaimur boundary, Mr. Auden reiterates his opinion of last year that the Susnai breccia occurs within and not at the base of the Kaimurs. He regards it as a sedimentary conglomerate made up of angular joint fragments and of rounded pebbles of porcellanite, similar to that found just below the present outcrop of the breccia. An exactly similar breccia was found at Barmori (24° 28′ : 83° 17′—not *in situ*) and at Hurma (24° 32′ : 82° 34′), in the middle of the glauconitic group of the Kheinjua stage, where there is no question of separating even one group from another. The Susnai horizon is last seen in a westerly direction at Gurdah (24° 35′ : 82° 59′), where the Susnai shales have died out and the two bands of quartzite belonging to the lower Kaimur sandstone stage have joined together. The breccia at Gurdah is not quite at the base of the united Lower Kaimur sandstone. The Semri-Kaimur boundary west of Gurdah is along the junction plane of the Rohtas limestone and the single Lower Kaimur sandstone. The actual junction plane is never seen, but there is no doubt that the two series are perfectly conformable. Still further west, the Bijaigarh shales decrease from their usual thickness of 150 feet to less than 70 feet, with the result that the scarps formed by the lower and upper groups of the Kaimur sandstone almost unite. At Bardi, these shales are stated by Mallet to die out completely.

Thoroughly weathered dolerites have been found high up in the Rohtas limestones west of Hurma. In all, four intrusions have been found in the Semri series. None has been seen in the Kaimurs. As Dr. Heron has suggested, the Semri rocks with their pyroclastic sediments and dolerite intrusions, may be equivalent to the Malani rhyolites of western Rajputana, in which are found dolerites that do not penetrate the overlying Upper Vindhyan sandstones.

Mr. Auden discusses the nature and origin of the glauconite in these Semri rocks. The mineral occurs either in pellet form, or interstitially, and is suggestive of the glauconitisation of rolled pellets of mud, and of the mud matrix between the sand grains. Frequent signs of bottom rolling are seen in the Fawn Limestone of the Kheinjua stage and in the Tirohan limestone. He comments on the presence of this mineral in shallow water and sub-aerially exposed sediments, comparing this with similar occurrences in Cambrian sediments of America and Sweden. True glauconite appears not

to have been found in rocks older than the Cambrian. Although there is no *a priori* reason to suppose that the mineral may not eventually be found in rocks of late Algonkian age, there is at least indication that the Vindhyan sediments may be Cambrian or younger. It seems generally to be accepted that the mineral only forms, at least initially before later redistribution, in sediments containing organic matter. Additional evidence is therefore given, aside from the presence of vitrain lenticles in Kaimur shales and of the Neemuch fossils, of the existence of life during Vindhyan times.

Further signs of arid conditions are seen in the marked freshness of felspars in the granite floor to the Semri rocks at Tirohan and in pebbles in the basal Semris.

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(*b*) Excursion to the Barakar area in the Raniganj Coalfield. *Op. cit.*, 180-182.

(*c*) Visit to the Bararee Coke Co., Ltd.'s Works. *Op. cit.*, 354-365.

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RUDISTÆ FROM EASTERN PERSIA. BY OTHMAR KÜHN, DR. PH., PROFESSOR, PALÆONTOLOGICAL SECTION MUSEUM OF NATURAL HISTORY, VIENNA. (With Plates 1 and 2.)

CONTENTS.

INTRODUCTION.

Rudistæ were first mentioned from Eastern Persia by Griesbach[1] in 1885 but no definite species were noted by him. In 1908, Vredenburg[2] described two species collected by Mr. I. R. I. Ward and Sir H. MacMahon from Kuh-i-Nahraru in Seistan. These were *Pironæa persica*, Vredenburg and a form which Vredenburg called *Hippurites gosaviensis*. This latter differs so much from *H. gosaviensis*, Douvillé, and in fact from any known form, that I have renamed it *Hippurites vredenburgi*.

In 1921, Mr. Tipper's paper 'The Geology and Mineral Resources of Eastern Persia' was published,[3] and in this were included brief notes regarding the occurrence of Hippuritic Limestone in the Kerman

[1] Griesbach, C. L., *Rec. Geol. Surv. Ind.*, XVIII, p. 60, (1885).
[2] Vredenburg, E. W., *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 26-29, (1908).
[3] *Rec. Geol. Surv. Ind.*, LIII, p. 51, (1921).

province. The limestone generally rests with decided unconformity on the Jurassic plant-bearing series,[1] the Lower Cretaceous being absent. Tipper states that 'Commencing at Abariq it runs almost continuously to Kerman, forms the upper scarp of the Damanu range and the Kuh-i-Badamu and most of the high hills in the district of Kuhistan' and that of the fossils 'it is only the Hippuritidæ and other Radistæ which are at all well-preserved.' Tipper, however, mentions no definite species.

In 1925, Dr. G. E. Pilgrim[2] published a new memoir on Eastern Persia and included in Chapter IV of this memoir is a brief description of the Hippuritic Limestone series, which he considered to be of Middle Cretaceous age. Of the three types of outcrop which he distinguished, only the first is of interest to us. This forms on the Persian plateau itself 'the prominent upper scarps of many of the hill ranges or, further north-west, even entire ranges.[3] Regarding the Hippuritic Limestones belonging to this class, Pilgrim gives only a reference to Tipper's paper; in describing the other types, he mentions only the generic names, *Durania* and *Radiolites*, of specimens occurring in the Khamir district.

In short, we see that in Eastern Persia no Rudistæ have been specifically determined and that, till now, we have no basis on which to decide the exact stratigraphical position of the Hippuritic Limestones and therefore also of the Semail, Dukhtar and Panj intrusive series.

During recent years, the geological staff of the Anglo-Persian Oil Company have studied the geology of Central and of parts of Eastern Persia and I have seen in the collections of Dr. G. M. Lees, Dr. K. Washington Gray, and Messrs. Jennings and Shaw a great number of Cretaceous fossils, but I have had no opportunity of studying them in any detail. As they are now possibly lost to science, it is rather fitting that I have been entrusted by the Geological Survey of India with the examination of the Rudistæ collected in 1912-13 by Mr. Tipper and I am greatly indebted to Dr. L. L. Fermor, Director, Geological Survey of India, for the necessary permission to prepare and examine them. I am also indebted to Mr. E. L. G. Clegg of the Geological Survey of India for transcribing and editing my manuscript.

[1] See Pilgrim, p. 58, with diagram 9, (1925).
[2] Pilgrim, G. E., *Mem. Geol. Surv. Ind.*, XLVIII, part 2, (1925).
[3] *Loc. cit.*, p. 59.

DESCRIPTION OF RUDISTÆ.

Family: HIPPURITIDÆ, Woodward.

Hippurites (*Vaccinites*) *chalmasi*, Douvillé.

1866. (*Hippurites toucasianus pars*), Zittel, Gosaugebilde, Pl. XXIII, fig. 5.
1897. Douvillé, Mém., p. 210; Pl. XXXIV, figs. 3, 4.
1907. (*Hippurites boehmi pars*), Toucas, Mém., text fig. 160.

There is no doubt that *Hippurites boehmi* and *H. chalmasi* are closely related to each other; but I do not agree with Toucas in uniting the two species. *Hippurites chalmasi* has a triangular form of the cardinal ridge, a character by which Douvillé was misled to compare it only with *Hippurites* of the *sulcatus* group. Also the first tooth and the muscular apophysis are completely contained in the space between the cardinal ridge and the first pillar.

Tipper's specimens differ only in magnitude from the forms described and figured by Douvillé. They have diameters of from 70-75 mm. whilst the figures of Douvillé show diameters varying only between 38 and 48 mm. In the text, Douvillé gives no measurements, but the form of the very characteristic first pillar and of the cardinal ridge, the position of the teeth and of the muscular apophysis are distinctly the same. Externally they show large ribs, which Douvillé has described as being the same as those of *H. gosaviensis.*

The species is known from the Gosau beds of Gams (Styria) and from Istria; it has a Santonian-Campanian age.

Locality: Badamu. (30° 21′ 56° 44′) W. of Kerman.

Geological map: Tipper, 1921, Pl. VI, Boeckh 1929, Pl. XXIII.

Description by Tipper, 1921, p. 59, 60, 72, with generalised section, Plate IV, fig. 2.

The collection from this locality is most numerous and includes 82 specimens.

G. S. I. Type No. 15,297.

Hippurites (*Vaccinites*) *conicus*, sp. nov.

(Plate 1, figs. 1 and 2).

Description.—Externally the lower valve shows fine ribs with a breadth of from 0·82 mm. opposite to the cardinal ridge and the pillars are two deep inflexions. The shell is very thin, never being more than 4 mm. thick. The height (without the upper valve) is in both specimens nearly 80 mm; cross sections near the upper rim

measure 88 × 61 mm. and 98 × 72 mm The cardinal ridge is very long and thin, the first pillar short and not pinched in at the base the second long and well developed The muscular apophysis is large and lies near the end of the cardinal ridge whilst none of the teeth are included in the area between the cardinal ridge and the first pillar

References. This is a Hippurite of the *dentatus* group. The cardinal ridge is longer and thinner than in all known species of that group, the form and position of the muscular apophysis is that of *H. marticensis* (Douvillé) Toucas, the exterior is that of *H. latus*, Matheron, whilst the rounded end of the cardinal ridge differentiates it from *H. marticensis*, the exterior and the muscular apophysis from *H. dentatus* and the form of the two pillars from *H. latus*.

The new species is certainly of Senonian age; of the nearest forms, *H. marticensis* is of Coniacian, *H dentatus* of Santonian and *H. latus* of Upper Santonian age.

Locality: Badamu.

G. S. I. Type No. 15,298.

Hippurites (Vaccinites) corbaricus, Douvillé.

1890. Mem., p. 9; Pl. II, fig. 1.
1903. Toucas, Mém., p. 85; Pl. XI, figs. 2, 2*a*; text figs. 132, 133.

A large specimen with a diameter of 96 mm. shows the characteristics of this species and especially the long cardinal ridge, the short but thick first pillar and the long pinched-in base of the second pillar. The part from the cardinal ridge to the second pillar is ⅛th of the whole circumference of the shell. On its surface, the lower valve has very fine ribs whilst the upper one shows the fine reticulated pores figured by Toucas.

The species is known only from the Coniacian of Southern France where it occurs with *Orbignya socialis*, *Vaccinites giganteus* and *V. marticensis*.

Locality: Badamu.

G. S. I. Type No. 15,299.

Hippurites (Vaccinites) rousseli, Douvillé, var. *batnensis*, Douv.

1910. Sicile. p. 13; Pl. II, fig. 5; text figs. 46-50.

The shell of this variety is often broken near the cardinal ridge and the pillars. Douvillé's figures 46-49 show this curious cir-

cumstance, whilst in Tipper's five specimens there is only one at all well preserved.

Douvillé has given no description of the exterior of the lower valve. The specimens which I have examined, show distinct ribs which have a thickness of from four to six mm. near the upper margin.

This species has up to the present only been known from the Lower Santonian of Batna in Algeria.

Locality: Badamu.

G. S. I. Type No. 15,300.

Hippurites (Vaccinites) vesiculosus, Woodward.

1855. Quart. Journ. Geol. Soc., p. 59, Pl. IV, fig. 6.

1865 (*Hipp. cornuvaccinum* and *H. organisans*) Vaillant, *Bull. Soc. Géol. France*, p. 280.

1897. Douvillé, Mém. p. 201, Pl. XXIX, figs. 7, 8, 8a, text fig. 71.

1903. Toucas, Mém., p. 110.

1913. Douvillé, Egypt, p. 244, Pl. XIV, fig. 2,[1] [*non* J. Boehm Bithyn. Halbinsel, p. 208, Pl. XVII, fig. 5, (1927)]

A colony, formed of several specimens, shows that this hippurite also forms reefs like many other, but not all, Rudistae. The specimens have a height of about 130 mm., diameters of from 35-50 mm. and shallow ribs of from 2-4 mm. The very thin shell, with a thickness of from 1-3 mm., the slightly undulating wall, the long and thin cardinal ridge, the position and form of the pillars show its specific position.

In some specimens, the cardinal ridge is broken, but the shell is intact and not broken, as figured by Douvillé and it is astonishing that, although the wall is uncommonly thin, it is quite resistant. Indeed it seems as if reef building were a mode of acquiring resistance, so that the species so occurring are often individually weaker than those which live alone *e.g.* *Vaccinites oppeli*, *Polyptychus morgani* and *lessi*, etc. Reef building forms, when discovered alone, as for instance in marls, seem always to be found broken, as is the case of the specimens of *V. vesicularis* described by Douvillé.

The species is known from the Campanian of Egypt (Djebel Attaka near Suez) and from Asia Minor (Hakim Khan). A specimen, described by J. Boehm from Bithynia, does not seem to belong

[1] *cf.* Douvillé, Pl. XXIX, figs. 8, 8-*a*, (1897); and Douvillé, Pl. XIV, fig. 2, (1913).

to this species. It differs especially in its cardinal ridge which is thickened at the end, and its generally pinched-in pillars; as also in its thicker shell (10 mm. instead of 1·3 mm. in *H. vesiculosus*) and its magnitude (100 mm. instead of 30-50 mm.) as these measurements are very constant in all specimens found till now.

Locality: Badamu.

G. S. I. Type No. 15,301.

Hippurites (Vaccinites) vredenburgi, sp. nov.

1909. (*Hippurites gosaviensis*) Douvillé *see* Vredenburg, Seistan, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 223, fig. 1; Pl. XIV, figs. 1, 2.

Description.—The specimens resemble in all details those described by Vredenburg as *Hippurites gosaviensis*, Douv. In comparing Vredenburg's figured specimens with those of *Hippurites gosaviensis* from the original locality and the figures of Douvillé, the following differences were noted:

1. The section of the test between the cardinal ridge and the second pillar is 1/3·5 of the whole circumference of the valve, whilst the same relation in *Hippurites gosaviensis* is ¼.
2. The cardinal ridge makes an angle with the line of the cardinal teeth of from 45°-55° instead of 30° as in *H. gosaviensis*.
3. In *H. gosaviensis* the sections of the circumference between the cardinal ridge and the first pillar and between the first and the second pillar are practically the same; in Vredenburg's form, the former is practically double the latter.[1]

All these differences are characteristic rather of *Hippurites giganteus* than of *H. gosaviensis*, although the posterior cardinal tooth and the posterior muscular apophysis of the specimens under examination are similar to those of *H. gosaviensis*.

[1] It is curious that Douvillé, who has noted the form of [Vredenburg Rudistes de Sicile etc., *Mém. Géol. Soc. France*, p. 83, (1910)], has not seen these differences. Vredenburg (*loc. cit.*, p. 224) states that from Douvillé's specimens of *V. gosaviensis*, one collected by Carez in the Corbiéres and figured in Douvillé's Mémoir (text fig. 15) is the most similar. But I found that Lanzia's specimen from Sebenico in Jugoslavia (Douvillé, Mém. Pl. XXIX, fig. 6) is the nearest, as the space between cardinal ridge and first pillar is 1½ times the space from the first to the second pillar.

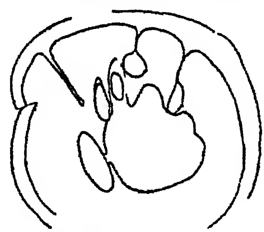
The cardinal ridge shown in Vredenburg's section (fig. 1) is truncated; in the text, Vredenburg states:[1] 'The cardinal ridge is long and slender and terminates somewhat irregularly.' I found that the cardinal ridge differs greatly in specimens that are similar in all other respects. It may be thin throughout its whole length, or thickened at the end; it may be round-ended or truncated, whilst it may vary so much in length as to be either longer or shorter than the first pillar.

The diameters of the lower valves in the specimens under examination measure from 55-85 mm. and show a much greater relationship to *H. giganteus* than to *H. gosaveinsis*. *Hippurites giganteus* is of Coniacian age and I prefer to consider the new species, which I have called *H. vredenburgi*, as belonging to that age rather than to the Upper Angoumian of *H. gosaviensis*.

The new species is abundant in the collection.

Locality: Badamu.

G. S. I. Type No. 15,302.



TEXT-FIG. 1.—*Hippurites vredenburgi*, sp. nov. Cross-section. Nat. size.

Hippurites (*Vaccinites ?*) *vredenburgi*, Kühn, *forma truncata*, nov.

There are many specimens in the collection, which resemble *Hippurites vredenburgi* in all respects—exterior, position of cardinal ridge and of the pillars, form of the pillars, position of teeth and posterior muscular apophysis. The cardinal ridge however is very much shorter than in *H. vredenburgi*. As the length of the cardinal ridge in *H. vredenburgi* has a great variability, it is possible that the specimens with short cardinal ridge are only an extreme variety, which might be placed, if one had not seen *H. vredenburgi*, in the subgenus *Orbignya*. It is possible, however, as the interior of the shell is filled with crystallised calcite, that the very thin cardinal

[1] *Loc. cit.*, p. 223.

ridge has been dissolved in the crystallisation process (*Diagenese*). Similar forms are known in literature, *e.g.* *Hippurites* (*Vaccinites*) *sp.* Douvillé (1913, Egypt, p. 13, Pl. II, fig. 4) from the Coniacian of Khenchela in Algeria, which is a *H. taburni*, Guiscardi of the same locality and the same external and internal characteristics as the typical form, but with a very short cardinal ridge, so that Douvillé states: 'J'ai hésité à faire de cette forme une espèce nouvelle; cependant la disposition du ligament correspond bien à une évolution plus avancée.' . . . .

I think it necessary to distinguish this form by a separate name, but not of specific or varietal value, as it seems possible to me that it is only a state of preservation. Therefore Douvillé's form is called also *H. taburni, forma truncata*, Kühn.

Locality: Badamu.

G. S. I. Type No. 15,303

TEXT FIG. 2.—*Hippurites vredenburgi, forma truncata*, nov. Cross section. Nat. size.

Hippurites (*Orbignya*) *tipperi* sp. nov

(Plate 1, fig. 4).

Description.—The upper valve shows large polygonal, sometimes slightly denticulated, pores and pustules. Externally the lower valve shows large and sharp ribs in a width of about 5 mm. near the upper margin. The cardinal ridge is very broad, the first pillar is long, nearly as long as the second, the latter not being pinched-in at the base.

References: There is a curious mixture of characteristics in this specimen. The pores are characteristic of the group of *Orbignya toucasi* and mostly similar to those of *Orb. sulcatoides*, Douv.,

the youngest species of the group The ribs are more like those of *Orb. carezi* Douv. and *Orb. præsulcatissima* Toucas, the cardinal ridge is that of *Orb. sulcatissima*, the second pillar resembles more *Orb. toucasi*, d'Orb. and *præsulcatissima*, Toucas. The first pillar only is not like that of any of the species; it is not so broad as in *O. toucasi*, *O. carezi*, *O. sulcatissima*, etc., and it is also not pinched in as in *O. prætoucasi*.

For this specimen I have created a new species, which may be by its close relations with *Orb. toucasi* and *Orb. carezi*, of Santonian age.

Locality: Badamu

G. S. I. Type No. 15,304.

Hippurites (Hippuritella) cornucopiae, Defrance.

(Plate 1 fig. 3.)

1821. (*Hippurites cornucopiae*) Defrance, Dict. Sc. Nat. p. 195; Pl. LVIII, bis, figs. 1a, 1b; *non* 1.
1827 (*Hippurites cornucopiae*) Blainville, Man. Malacol. p. 196; Pl. LXXXIII, figs. 1a. 1b; *non* 1 ? (cf. Defrance 1821).[1]
1882. (*Hippurites cornucopiae*) de Gregorio, Dinterni di Pachino, p. 6; Pl. III; Pl. IV, figs. 7, 8; Pl. V, figs. 14, 16, 19; Pl. VI, figs. 29, 31.
1897 (*Hippurites cornucopiae*) Douvillé, Mém. p. 223, fig. 72; Pl. XXXII, figs. 11, 12, (*non* p. 85; Pl. XIV, figs. 1-4; Pl. XV, figs 2, 3).
1900 (*Hippurites cornucopiae*) Parona, Appenin Meridion., p. 10; Pl 1, fig. 1.
1903. (*Orbignya cornucopiae*) Toucas, Mém. p 54 fig. 85.
1904. (*Hippurites cornucopiae*) Douvillé, Mission de Morgan, p. 359; Pl. XXXIX, fig. 1 (cf. Douvillé, 1897, Pl. XXXII, figs. 11, 12).
1910. (*Hippuritella cornucopiae*) Douvillé, Sicile, p. 79; Pl. VII, figs. 3, 4, 5.
1930. Zuffardi-Comerci, Puglia, p. 9.

This specimen has the same interior as the forms described and figured by Douvillé and Toucas; it has however irregular and widely spread ribs on the exterior[1] which are reminiscent of *H. colliciata*, Woodward. This difference seems to me insufficient to create a new species, although Douvillé has figured a specimen from Persia, which shows no ribs (1897, Pl. XXXII, fig. 12).

Hippuritella cornucopiae is known from the Mæstrichtian of Italy, Sicily and from Luristan.

Locality: Badamu.

G. S. I. Type No. 15,305.

[1] See Pl. 1, fig. 3.

Hippurites (Hippuritella) grossouvrei, Douvillé.

1891. Mém., p. 118; Pl. XVIII, figs. 1-4.
1903. Toucas, Mém., p. 97; Pl. XIV, figs. 1, 1a, 2; text figs. 152, 153.
1910. Douvillé, Sicile, p. 67; text figs. 69, 70.

The specimens are practically identical with those described by Douvillé and Toucas. The slightly varying length of the cardinal ridge in different specimens must, following Douvillé[1] be attributed only to different stages of growth.

The species is known from the upper Angoumian of the Corbieres and of the Lebanon.

Locality: Badamu.

G. S. I. Type No. 15,306.

Hippurites (Pironaea) persica, Vredenburg.

1909-10. Seistan, *Rec. Geol. Surv. Ind.*, p. 226, fig. 2; Pl. XV, figs. 1-3.
1910. Douvillé, Sicile, p. 83.

Description.—Two specimens show the general form and external characteristics of Vredenburg's species; one is however somewhat larger and has diameters of from 5 to 6·8 cm. In this latter specimen the pillars are of subnormal length, but this small difference does not seem sufficient to differentiate it from the species. All specimens show feebler inflections of the wall than the form figured by Vredenburg; but this slight difference is again not sufficiently great to be of specific value.

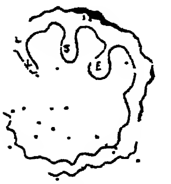
Pironaea persica is distinguished from the related species *P. polystyla*, Pirona, *P. polystyla var. slavonica* (Hilber), Kühn and *P. corrugata*, Woodward by its feeble inflections and the almost complete absence of secondary inflections.

The species was found by Vredenburg at Koh-i-Nahrahn on the north-western margin of the Seistan swamps near the Persian-Afghan frontier. The specimens of Tipper were found not far distant from the same locality.

Locality: Badamu.

G. S. I. Type No. 15,307.

[1] Douvillé, p. 9, (1910).



TEXT-FIG. 3.—Section of *Pironaea persica*, Vredenburg. L-cardinal ridge, S- first pillar E- second pillar.

Family : RADIOLITIDÆ, Gray.

Eoradiolites cf. lyratus (Conrad) Douv.

1852. (*Hippurites lyratus*) Conrad, Off, Rep. U. S., p. 234; Pl. VII, figs. 47, 48.
1883. (*Sphaerulites schweinfurthi*) Zittel, Lib. Wüste, p. 79.
1886. (*Radiolites syriacus*) Nœtling, *Zeit. deutsch. geol. Ges*, XXXVIII, p. 842.
1890. (*Sphaerulites sauvagesi*) Blanckenhorn, Syrien, p. 86.
1891. (*Hippurites lyratus*) Whitfield, Beyrouth District, p. 385.
1900. (*Sphaerulites lyratus*) J. Bœhm, Libanon, p. 219.
1904. (*Sauvagesia nicaisei var. schweinfurthi*) Douvillé, *Bull. Soc. géol. France*, p. 174.
1907. (*Sauvagesia nicaisei, forma juv.*) Toucas, Mém., p. 126.
1909. Parona, Siria, p. 4; Pl. 1, figs. 1-6.
1910. Douvillé, Sicile, p. 70; Pl. 1, figs. 2-4; Pl. IV, fig. 6; Pl. V, fig. 3.
1912. (*cf.*) Parona, Anticolana, p. 11 ; text figs. 7, 8.
1913. Douvillé, Egypte, p. 244; Pl. XIV, figs. 3-11; Pl. XVI, fig. 8; text fig. 6.
1923. Parona, Medea, p. 150.
1926. Douvillé, Afghanistan, p. 246 ; Pl. XII, figs. la, b.
1926. Parona, Istria, p. 33; Pl. III, fig. 10.
1928. Klinghardt, Rudisten Entwicklungsstudien, p. 173; Pl. XV, figs. 1-2; Pl. XVI, figs. 3-8.
1929. Klinghardt, *Palaeontographica*, p. 99; Pl. XIII, fig. 3; Pl. XIV, figs. 1, 3.
1930. Zuffardi-Comerci, Puglia, p. 10.

I regret that this fossil, so important for stratigraphical purposes, is very badly preserved, so that it cannot be accurately determined. In the larger specimen (height, 60 mm.; diameter of the body cavity, 40 mm.) the shell with the two siphonal grooves is lacking, only the cavity with the cardinal ridge being visible.

A smaller specimen (height, 15 mm., incomplete; diameter, 11 mm.) is also an internal cast; it is very similar to the former and may be of the same species.

Locality : Begaijan (31° 5′ : 56° 44′). Geol. map : Tipper, Plate VI, (1921). Description : *ibid.* p. 60.

The collection includes also a *Trigonia* and a *Pecten*.

Locality: Abariq Kuh (29° 19′ 58° 55′) West of Bam.

No description: only mentioned by Tipper (1921), p. 62 and Pilgrim (1925), p. 68.

G. S. I. Type No. 15,308.

Durania inermis (Douvillé).

1913. (*Durania humei* var. *inermis*) Douvillé, Egypte, p. 255; Pl. XVI, figs. 6, 7, 7a.

Description.—Upper valve unknown: lower valve subconical, very plain with smooth ornamentation. Siphonal grooves large and shallow; the area between them is also very low and difficult to see.

References: Douvillé has considered this form a variety of his *D. humei*, but in my opinion, the shallow and large evolution of the siphonal grooves and included area are most important characteristics, which show closer relations to other species than to *D. humei*. The tissue of the shell seems to be slightly finer in our specimen than in the form from Egypt; but this is certainly a difference of little note.

The species is known only from the western side of the Sinai mountains, from shales of Turonian age.

Locality: Darmanu range, opposite Sir-i-Asiab Shish.

G. S. I. Type No. 15,309.

Durania laevis, Douvillé.

1867. (*Radiolites mortoni*) Fraas, Aus dem Orient.

1890. (*Sphaerulites mortoni*) Blanckenhorn, Syrien, p. 85.

1910. Douvillé, Sicile, p. 75; Pl. V, figs. 1, 2.

The measurements of two specimens from Tipper's collection are shown in millimetres in the following table:—

—	Specimen I.	Specimen II.
Height	70	65
Greatest diameter	100	72
Shortest diameter	50	58
Thickness of the shell	15	18

The exterior is nearly prismatic and not the usual cylindro-conical one of Rudistae. The channels, described by Douvillé in the cortical zone of the shell, are rare and not easily seen.

The species is known only from Syria and is of Cenomanian age.

Locality: Badamu.

G. S. I. Type No. 15,310.

Durania major, sp. nov.

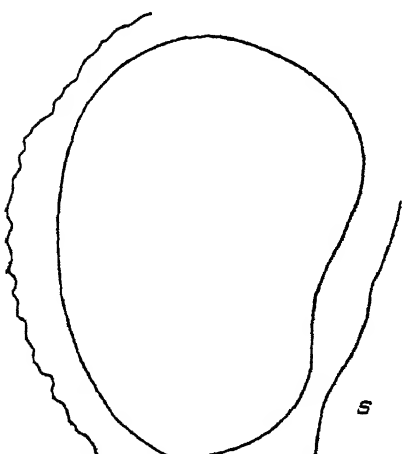
Description.—Upper valve unknown, lower valve subconical, height 100 mm., cross-section irregular, 140×95 mm. The shell is thin and shows fine channels, in some spaces very numerous, (nine to a length of five mm.) in other spaces the usual tissue. The siphonal grooves are short, but deep.

References: The specimens are similar to the European species *D. cornupastoris* (Des Moulins), which also attains diameters of 110 mm. and to *D. lævis* Douvillé, previously mentioned. The latter shows in the shell the same fine radial channels, but they are lacking in *D. cornupastoris*. In the species under examination, the channels are however not rare as in *D. lævis*, but very common. The shell is also very much thinner in relation to the diameter of the cavity, than in all other species.

The absence of a cardinal ridge, the tissue of the shell and the form of the two siphonal grooves show the generic position of the specimens.

Locality: Badamu.

G. S. I. Type No. 15,311.



TEXT-FIG. 4.—*Durania major*, sp. nov. ½ nat. size.

TEXT-FIG. 5.—*Durania major*, sp. nov. Portion of the shell. Nat. size.

Sub-Family. LAPEIROUSEIINÆ, nov.

The occurrence of the so-called pseudo-pillars in the genus *Lapeirouseia*, Bayle and in a new genus, here described, seems to be of great importance. There is no doubt that these two channels are siphonal grooves but internally situated, similar to those of the family Hippuritidæ. They are developed however in a different manner and the ligamental groove of the Hippuritidæ is lacking.

The new family seems to be a branch of Rudistæ in convergent evolution with the Hippuritidæ; but it is certainly of younger age and therefore has not had so long a time for specialisation and is not so widely distributed as that family. It has no direct connection with the Hippuritidæ, but is derived from *Sauvagesia*.

It appears to be distributed only in the oriental region from the Alps to Eastern Persia and to be restricted to the Senonian age.

Genus: *Lapeirouseia*, Bayle.

Although very characteristic, the genus *Lapeirouseia* has no specific diagnosis. The name was first employed by E. Bayle in the explanation of *L. jouanetti*.[1] Toucas in his great memoir[2] has joined it with *Sphærulites*, but Douvillé[3] has drawn attention to certain differences and allowed the genus to stand. Douvillé states:—'Il est caracterisé par l'absence d'arête cardinale et par la presence de deux renflements internes regulièrement arrondis au droit des aires siphonales: ce sont des pseudopiliers auxquels correspondent des oscules sur la valve supérieure.'

In practically the same words Pervinquière[4] states:—"Il est caracterisé par l'absence d'arête cardinale et par la presence de deux pseudopiliers au droit des aires siphonales, auxquels correspondent deux oscules à la valve supérieure."

Pervinquière had already drawn attention to the fact that the name of the genus is correctly *Lapeirouseia* and not Lapeirousia, the name which was employed till now by Bayle, Douvillé and Toucas.

The type-species is *Radiolites jouanetti*, Des Moulins, whilst the other known species are:—

Lapeirouseia aumalensis, Douv.

[1] E. Bayle, *Expl. Carte géol. de la France*, IV b, Pl. CX, CXI, (1878).
[2] Toucas, Mém., p. 49, (1907).
[3] Douvillé, Sicile, p. 25, (1910).
[4] Pervinquière, Tunis, p. 326, (1912).

Lapeirouseia crateriformis (Des Moulins), Douv.
" *fallax*, Douv. 1915 (=*L. zitteli*, Douv. 1913).
" *nicolasi*, Whitfield.
" *pervinquièrei* (Toucas), Douv.
" *zitteli*, Douv.

Osculigera, gen. nov.

There is a new and very interesting form, which I have previously seen in material collected by the geological staff of the Anglo-Persian Oil Company in Central and Eastern Persia. It is similar to the genus *Lapeirouseia*, Bayle, but differs in many important respects.

Diagnosis ; General form, flat or cylindro-conical, lamellate or striated ; cross-section, sub-circular.

Cavity of the lower valve irregular, with two inflexions near the primary pseudo-pillars ; sometimes it possesses small inflexions near the secondary pseudo-pillars. Large, or primary pseudo-pillars of the same evolution as in *Lapeirouseia* or branched, so that some osculæ may be seen in cross-section and probably also in the upper valve.

Type-species : *Osculigera cleggi*, sp. nov.

We have previously remarked that the possession of only two pseudo-pillars is the most important criterion of the genus *Lapeirouseia* in all descriptions. Our example, which shows a great number of pseudo-pillars of smaller size besides these two primary pseudo-pillars, must therefore be regarded the type of a new genus.

Osculigera cleggi, sp. nov.

(Plate 2, fig. 2.)

Description.—Upper valve unknown : lower valve subconical, height 40 mm., diameter 68 mm.; greatest diameter of the cavity 32 mm. Diameter of the meshes of the very fine cortical tissue from 0·2-0·5 mm. ; pseudo-pillars completely closed, a significance of adult specimens[1] ; primary pseudo-pillars very large, greatest diameter about 10 mm., lying on the large inflexions of the cavity ; the secondary are very much smaller, rounded, and have diameters of from 1·5-2·5mm.; they are regularly arranged at intervals of about 9 mm.

Locality : Badamu.

G. S. I. Type No. 15,312.

[1] See Douvillé p. 26, (1910).

Osculigera hippuritiformis, sp. nov.

(Plate 2, figs. 4 and 5.)

Description. Upper valve unknown. Lower valve large, sub-cylindrical, externally decorated with fine, subequal ribs numbering eight to three millimetres of the circumference; fine horizontal lamellæ are only seen with a lens. Shell thick, the meshes of the tissue very fine, five to two millimetres. The cavity has two deep inflexions opposite to the two primary pseudo-pillars. Secondary pseudo-pillars very small, at distances of from 12-18 mm. from one another and in very varying distances from the body cavity.

This is a very singular form of a lapeirouseid rudist, the others being flat and showing only the horizontal lamellæ or large ribs. We know, however, that in other genera there are also forms which resemble *Hippurites* in external form.

Locality: Abriq Kuh.

G. S. I. Type No. 15,313.

Osculigera magna, sp. nov.

(Plate 2, fig. 1.)

Description.—Upper valve unknown: lower valve very massive: measurements as follows in millimetres:—

—	Specimen I.	Specimen II.
Height	70	63
Greatest diameter	105	110
Shortest diameter	83	76
Meshes of the tissue	4-5	4-5
Diameter of the body cavity	35×37	22×35

The shell is thick and shows externally large lamellæ in the same manner as the well-known species of *Lapeirouseia jouanetti* and *L. crateriformis*. The primary pseudo-pillars are very large, 11-12 by 6·5-7 mm., lying on slight inflexions of the cavity: secondary

pseudo-pillars, 2 mm. in diameter, 10-14 mm. distant from one another, one of them lying between the two primary pseudo-pillars is branched vertically, so that in cross-section a radial series of four osculæ is seen, the internal one being the greatest and the external the smallest, with a diameter of 0·8 mm.

By these characters and especially by this branched secondary pseudo-pillar, this form is clearly distinguished from all other species. In the collection of Dr. K. Washington Gray of the Anglo-Persian Oil Company, I have seen a similar form from Niband[1] which may possibly be of the same species. It was there the only fossil in a large series of sandstones and limestones.

Locality : Badamu.

The specimens of the genus previously seen by me, seemed to belong to a bigger species having regularly branched primary pseudo-pillars. They were collected in the Niriz country by Mr. Shaw.

G. S. I. Type Nos. 15,314 and 15,315.

STRATIGRAPHICAL CONCLUSIONS.

The small fauna here described contains specimens of 17 species and one variety, of which one is of certain Cenomanian, two of Turonian and five of Senonian age ; the age of the others is uncertain.

Name.	Number of specimens.	Locality.	Other localities.	Age.
Hippurites (*Vaccinites*) *chalmasi*, Douv.	3	Badamu	Gosauform. Istria .	Santon. —Campanian.
Hippurites (*Vaccinites*) *conicus*, sp. nov.	3	„	....	Senonian ?
Hippurites (*Vaccinites*) *corbaricus*, Douv.	1	„	Southern France .	Coniacian.
Hippurites (*Vaccinites*) *rousseli* var. *batnensis*, Douv.	5	„	Algeria . . .	Santonian.
Hippurites (*Vaccinites*) *vesiculosus*, Woodw.	4	„	Egypt, Asia Minor .	Campanian.
Hippurites (*Vaccinites*) *vredenburgi*, sp. nov.	..	„	Seistan . . .	?
Hippurites (*Vaccinites*) *vredenburgi*, forma.	..	„	....	?
Hippurites (*Orbignya*) *tipperi*, sp. nov.	1	„	....	?

[1] Chehil-Painear Naiband, between the Dasht-i-Kevir and the Dasht-i-Lut. Geol. map : de Bœckh, Plate XXIII, (1929).

Name.	Number of specimens.	Locality.	Other localities.	Age.
Hippurites (Hippuritella) cornucopiae, Defrance.	1	Badamu	Luristan, Sicily, Italy.	Maestrichtian.
Hippurites (Hippuritella) grossouvrei, Douv.	1	„	Lebanon, Corbières .	Turonian.
Hippurites (Pironaea) persica, Vred.	8	„	Seistan . . .	?
Eoradiolites cf. liratus (Conrad) Douv.	2	Abariq Kuh Begaljan.	N-Afghanistan, Sinai, Egypt, Italy, Istria.	Cenomanian—Turonian.
Durania inermis (Douv.), sp. nov.	1	Darma Range	Sinai . . .	Turonian.
Durania laevis, Douv. .	2	Badamu	Syria . . .	Cenomanian.
Durania major, sp. nov.	2	„	....	?
Osculigera cleggi, sp. nov.	1	„	....	?
Osculigera hippuritiformis, sp. nov.	1	Abariq Kuh	....	?
Osculigera magna, sp. nov.	2	..	....	?

As the Rudistae are always considered to be of important stratigraphical value, we must conclude that the 'Hippuritic limestones' of Eastern Persia range in age from the Cenomanian to the Senonian. They are certainly not entirely of Middle Cretaceous age, as Pilgrim suggests.[1] The Senonian is represented by most characteristic species, such as *Hippurites corbaricus*, *H. vesiculosus*, *H. cornucopiae*.

It is a question of great importance how much of the Senonian is present. For there are three eruptive series, the Semail, the Dukhtar and the Panj series, of which the exact age is unknown, between the Hippuritic limestone and the overlying Eocene (Ginau shales, Zindan series, probably Middle Eocene). Pilgrim suggests that these eruptive series are of Upper Cretaceous age.[2] The uppermost horizon as determined by fossils (*Hippurites cornucopiae*) is Maestrichtian. Even supposing that *Hippurites cornucopiae* differs a little from the type, the Maestrichtian is determined in the adjoining Cretaceous series of Niriz, which I have studied in the collection of Mr. M. G. Shaw, by the typical and abundant *Hippurites cornucopiae*, by *Polyptychus morgani*, *Loftusia morgani* and *Omphalocyclus macropora*. It is therefore at least definite in this adjoining country and therefore also probably in the Kerman district.

[1] *Loc. cit.*, p. 59.
[2] *Loc. cit.*, pp. 63, 67, 72.

The eruptions must therefore be restricted to the time between the Mæstrichtian and the Eocene, *i.e.*, to Danian and Paleocene time. This time seems sufficient for the assembly of a great series of igneous rocks. We must also bear in mind that in the Dukhtar series there are limestones interbedded with the eruptive rocks, so that certainly a part of the eruptions were continuing under conditions of marine submergence.

THE RUDISTID STRATA OF ASIA.

The centre of evolution of the Rudistæ appears to have been situated in the western part of the Tethys, the greatest number of all known species being found in France, Italy and in the Alps. From Northern Africa (Algeria, Tunis, Tripoli, Egypt) and the adjoining parts of Asia (Sinai Peninsula, Syria) Rudistæ have also been described, the latter by Fraas, Blanckenhorn and more exactly by Douvillé.

Woodward[1] first described the species collected by Loftus from Hakhim Khan in Asia Minor: *Hippurites loftusi, H. colliciatus, H. corrugatus, H. vesiculosus.* Some years later d'Archiac mentioned in Tchihatcheff's 'Asie Mineure'[2] three species of *Hippurites cornuvaccinum, Sphaerulites peillettci* and *Sphaerulites ponsiana* but included no figures nor descriptions, so that it is impossible to say how exact his determinations were. The first species was certainly not *H. cornuvaccinum* but was probably *H. gosaviensis,* or possibly the new species *H. vredenburgi.*

Frech[3] mentioned the occurrence of Rudistæ (*Biradiolites, Radiolites, Sauvagesia, Sphaerucaprina*) in the Upper Cretaceous of the Taurus and of Pamphylia. In Bithynia there is a fauna well-known by. the work of J. Bœhm, 1927. It contains *Sabinia klinghardti Schiosiabilinguis, Hippurites gosaviensis var. tenuicostata, Hippurites bithynicus,* sp.[4] nov., *H. blanckenhorni, Praradiolites cf. sinuatus* (d'Orb) *Radiolites endrissi, R. angeiodes* (1ic. de Lap.), *R.* cf. *subangeiodes,* Toucas, *Biradiolites scyphus, Durania* cf. *spadai,* Parona.

[1] Woodward, S. P., pp. 58-59, (1855).
[2] pp. 86, 95, 97 from Amasia and Niksar.
[3] Frech, pp. 266, 267, 296, (1916).
[4] *Hippurites bithynicus,* nov. spec. Kühn.—*H. vesiculosus,* J. Bœhm, p. 208; Pl. XVII, fig. 5; *non* Woodward, (1927).
I have previously stated that Bœhm's specimen differs in many important characters from the species of Woodward and I have accordingly made a new species for the form.

In recent years, E. Nowak has collected Rudistæ from the Cretaceous of Anatolia, but no description of these has yet been published.

Rudistæ have often been mentioned from the Karabagh plateau of Armenia, firstly by Abich in 1859,[1] whilst in 1867 the same author[2] mentions *Radiolites mortoni* from Alikulikut and[3] *Hippurites cf. cornuvaccinum* from N.N.W. of Nakhicheron. Sorokin, 1877,[4] mentions *Caprina aguilloni* from the same district, whilst in 1900 Anthula [5] mentions *Radiolites mortoni* determined from the collection of Abich. In his last memoir[6] Abich himself has given two figures of Rudistæ on Plate VII, called "Turonfossilien aus Karabag," but no explanations and even no names. His figure 1 is probably the form previously called by him *Hippurites cf. cornuvaccinum* from Nakhicheron. The figure is not characteristic and it is only possible to say of it, that it is certainly not *Hippurites cornuvaccinum*. Figure 3 is probably the form often mentioned as *Radiolites mortoni* and is most probably *Durania austinensis*, as the form of the shell and of the cavity, of the siphonal grooves and of the area between them, of the branched channels in the shell and even the measurements are the same as in that species. Oswald in his treatise on the geology of Armenia [7] has only repeated the former statements.

From Turkestan the first Rudistæ are described by Romanowsky, who[8] mentioned or described from Ferghana, *Caprotina toucasiana*, *C. plauensis*, *Caprina adversa*, *Radiolites hœninghausi*, *R. germari*, and from Sarvadane *Caprotina toucasiana*, *C. plauensis*, *Radiolites agariciformis*, *R. polyconilites*, *R. saxoniæ*, *R. hœninhausi*, *R. germari*. This association seems to indicate a northern aspect of the fauna, not astonishing in this country. But Henri Douvillé[9] has stated that the determinations were based upon badly preserved shells, and the latter in new collections from Ferghana could only determine *Biradiolites praæingens* and *Apricardia archiaci*, two species of a southern type.

[1] Abich, p. 123, (1859): 'Im Dardys Dagh oberhalb Gerger *Radiolites socialis*, fragmente von *Hippurites* und *Caprotina*;' p. 124, 'bei Alikulikent im S. Karabagh *Plagioptychus aguilloni* und grosse *Radiolites*.'

[2] Abich, p. 33, (1867).

[3] *Ibid.*, p. 40.

[4] Sorokin, p. 62, (1877).

[5] Anthula, p. 143, (1900).

[6] Abich, Pl. VII, (1887).

[7] F. Oswald, pp. 356, 357, (1906).

[8] Romanowsky, pp. 99, 100, (1880); and pp. 97-101, (1884).

[9] pp. 392 and 395, (1914).

From Western Persia (Bakhtyari and Luristan) Douvillé has described in two publications[1] the following species: *Hippurites cornucopiae*, Defr., *H. morgani*, Douv., *Lapeirouseia jouanetti* (Des Moulins), *Radiolites trigeri*, Coq., *R. peroni*, Choffat, *R. morgani*, Douv., *Præradiolites ponsianus*, d'Arch., *P.* sp., *Bournonia* sp., *Durania austinensis* (Rœmer), *Biradiolites lombricalis*, d'Orb., *B. persicus*, Douv., *Polyptychus morgani*, Douv., and *P. striatus*, Douv.

In the previously mentioned collection of Mr. Shaw from Central Persia and especially from the Niriz country I was able to identify:—

Hippurites cornucopiæ, Defrance.
Hippurites morgani, Douv.
Lapeirouseia pervinquierei (Toucas) Douv.
Osculigera, sp. nov.
Præradiolites hœnighausi (Des Moul.) Toucas.
Durania austinensis (Rœmer).
Polyptychus morgani, Douv.

Besides these, I observed a number of species of *Durania* and *Bournonia*, which latter two genera seemed to dominate, the Hippuritidœ being very rare, whilst in Tipper's material, the latter are dominant. I also observed in Mr. Shaw's collection the following.

Anthozoa:
Cyclolites undulata var. *robusta* (Quenstedt).
,, *numismalis*, Lam.
,, *medlicotti*, Nœtling.
,, *scutellum*, Reuss.
,, *angistoma*, sp. nov.
Aspidiscus orientalis, sp. nov.
Cycloseris lamellata, sp. nov.
Palæopsammia fastigiata, sp. nov.
Trochosmilia inflexa, Reuss.
,, *brevicula*, Stol.
Bryozoa: div. spec.
Brachiopoda:
Terebratula biplicata, Sow. var. *dutempleana*, Stol.
,, *sub-depressa*, Stol.
,, cf. *toucasi*, d'Orb.
Kingena shalanurensis, Stol.

[1] Douvillé (1904) and (1910).

Echinodermata:
Salenia cf. *cossiae*, Cotteau & Gauthier.
Orthopsis morgani, Cotteau & Gauthier.
Pyrina orientalis, Cotteau & Gauthier.
Hemipneustes cf. *minor*, Cotteau & Gauthier.
Iraniaster sp.

Mollusca:
Cardium sp.
Inoceramus sp.
Neithea sp.
Spondylus subserratus, Douv.
Ostrea sp.
Exogyra sp.
Alectryonia pectinata, Lam.
Tectus tamulicus, Stol.
Nerita carolina, Stol.
Natica bulbiformis, Sow.
Pugnellus sp.
Actaeonella cylindrica, Stol.

From Eastern Persia, the only fauna described is in the present paper by myself and includes:

Hippurites (*Vaccinites*) *chalmasi*, Douv.
" " *conicus*, sp. nov.
" " *corbaricus*, Douv.
" " *rousseli* var. *balnensis*, Douv.
" " *vesiculosus*, Woodward.
" " *vredenburgi*, sp. nov.
" " " *forma truncata*, sp. nov.
" (*Orbignya*) *tipperi*, sp. nov.
" (*Hippuritella*) *cornucopiae*, Defrance.
" " *grossouvrei*, Douv.
" (*Pironaea*) *persica*, Vredenburg.
Eoradiolites cf. *lyratus* (Conrad) Douv.
Durania inermis (Douv.).
" *laevis*, Douv.
" *major*, sp. nov.
Osculigera cleggi, sp. nov.
" *hippuritiformis*, sp. nov.
" *magna*, sp. nov.

From Baluchistan, Nœtling[1] has described two forms *Radiolites subdilata* and *R. muschketoffi*—but which in view of the remarks of Douvillé[2] must be regarded as indeterminable. Later Vredenburg has described from Seistan :[3]

Hippurites (*Vaccinites*) *gosaviensis* (=*H. vredenburgi*, Kühn.)
„ (*Pironaea*) *persica*, Vred.

South of Herat in Afghanistan H. H. Hayden[4] first mentions rudistid limestones, from which Douvillé described :[5]

Eoradiolites lyratus (Conrad).
Apricardia nœtlingi (Blanckenh) and *Sphaerulites griesbachi*, Douv.

whilst from Kashmir and the Pamirs the same author[6] described the new species :

Horiopleura haydeni and *Præradiolites gilgitensis.*

From South-Western Tibet, Douvillé described[7] Lower Cretaceous shales with *Præradiolites hedini*, Douv., from Central Tibet[8] Campanian with *Bournonia haydeni*, Douv., and *Bournonia tibetica*, Douv. and Mæstrichtian with *Plagioptychus tibeticus*, Douv.

From the Karakoram, Parona has mentioned[9] *Radiolites indicus*, Stol., *R. peroni* (Choffat), *Durania* cf. *arnaudi*, Choffat, *Gyropleura cenomanensis* (d'Orb).

From Southern Persia, Richardson[10] has mentioned some Rudistæ from Khamir, which have been tentatively determined by Dr. A. Douglas :

cf. *Caprinella dublieri*, d'Orb.
cf. *Durania lævis*, Douv.
cf. *Durania mortoni*, Douv. (probably *D. austinensis*.)
cf. *Sauvagesia præsharpei*, Toucas.
cf. *Sauvagesia nicaisai*, Coq.

and are therefore Cenomanian—Turonian forms.

From Oman, a country which belongs to Asia not only in geographical, but also in a geological sense, A. V. Krafft[11] found limestones

[1] Nœtling, pp. 50, 51, (1902).
[2] Douvillé, p. 392, (1914).
[3] Vredenburg, *Rec. Geol. Surv. Ind.*, p. 220, (1909).
[4] Hayden, *Mem. Geol. Surv. Ind.*, p. 34, (1911).
[5] Douvillé, *Rec. Geol. Surv. Ind.*, p. 345, (1926).
[6] Douvillé, *Rec. Geol. Surv. Ind.*, p. 349, (1926).
[7] In Sven Hedin, (1911), and *Comptes rendus Soc. Géol. France*, p. 58, (1924).
[8] Douvillé, *Pal. Indica*, pp. 9, 11, 15, (1916).
[9] Parona, p. 55, (1917).
[10] Richardson, p. 18, (1926).
[11] Pilgrim, p. 15, (1908).

near Kalhat with *Radiolites* sp. From the Jabal-al-Millah, I[1] described :

Hippurites (Vaccinites) paronai and

Polyptychus le si.

with a fauna of apparently Mæstrichtian age.

Eastern Persia and Oman seem to be on the eastern boundary of areas in which Rudistæ are common. In the well developed and fossiliferous Cretaceous series of India, only two rudists have been described.[2]

Sphaerulites indica, Stol. and

Radiolites mutabilis, Stol.

According to Douvillé[3], they are in a bad state of preservation, the former being indeterminable whilst the second is a *Bournonia* of the *bournoni*-group.

However, even in the Malayan Archipelago rudistid limestones are often mentioned and some species of *Radiolites* and *Sphaerulites* of Upper Cretaceous age are described.[4]

In eastern Asia only a continental facies of the Cretaceous is present, but in Japan, some Lower Cretaceous Rudistæ have been described.[5]

In conclusion we may state, that Rudistæ are not rarer in Asia [6] than in the Cretaceous strata of Europe or of America, although in the Cretaceous strata of India the almost entire absence of Rudistæ is inexplicable.

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[1] Kühn, p. 18, (1920).
[2] Stoliczka, (1873).
[3] Douvillé, p. 83, (1910).
[4] Martin, pp. 121-125 a. o., (1889).
[5] By Yabe and Nagao in the last years.
[6] The map of the distribution of rudists given by R. H. Palmer (The Rudists of southern Mexico, *Occasional Papers of the Calif. Acad. of Sc.*, Vol. XIV, p. 18, (1928)) is not quite correct; the habitats of Turkestan, Karakoram and the Pamirs are lacking and also those of Southern Sweden and Eastern Africa. Better is the earlier map of E. Dacqui (Grundlagen und Methoden der Palæogeographie, Feud, p. 424, (1915)).

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EXPLANATION OF PLATES.

PLATE 1.—Figs. 1 & 2.—*Hippurites* (*Vaccinites*) *conicus*, nov. spec. ($\frac{2}{3}$ nat. size).

Fig. 3.—*Hippurites* (*Hippuritella*) *cornucopiae*, Defrance.

Fig. 4.—*Hippurites tipperi*, nov. spec. (approx. $\frac{2}{3}$ nat. size). L= cardinal ridge, E and S=pillars.

PLATE 2.—Fig. 1.—*Osculigera magna* nov. spec. ($\frac{2}{3}$ nat. size).

Figs. 2 & 3.—*Osculigera cleggi*, nov. spec. ($\frac{2}{3}$ nat. size).

Figs. 4 & 5.—*Osculigera hippuritiformis*, nov. spec. ($\frac{2}{3}$ nat. size).

FIGS. 1 & 2. HIPPURITES (VACCINITES) CONICUS, *nov. spec.* 2/3 nat. size.

FIG. 3. HIPPURITES (HIPPURITELLA) CORNUCOPIÆ, Defrance.

FIG. 4. HIPPURITES TIPPERI, *nov. spec.* approx. 2/3 nat. size.

L. cardinal ridge, E. and S. - pillars.

Fig 1

Fig 3

Fig 2

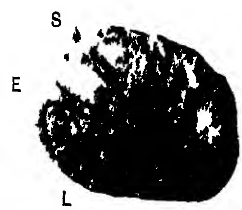

Fig 4

O Kuhn Photos

G S I Calcutt

FIGS 1 & 2 HIPPURITES (VACCINITES) CONICUS, *nov spec* 2/3 nat size

FIG 3 HIPPURITES (HIPPURITELLA), *Cornucopiæ defr anc*

FIG 4 HIPPURITES TIPPERI, *nov spec* approx 2/3 nat size

L = cardinal ridge, E and S = pillars

Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

O Kühl Photos

G S I Calcutta

FIG 1 OSCULIGERA MAGNA, *nov sp c* 2/3 nat size

FIGS 2 & 3 OSCULIGERA CLEGGI *nov spec* 2/3 nat size

FIGS 4 & 5 OSCULIGERA HIPPURITIFORMIS. *nov spec* 2/3 nat size

ERRATA.

RECORDS, GEOL. SURV. IND., Vol. LXV, Part 4.

Page 451, line 8, *for* 'fig. 2' *read* 'fig. 1.'

Page 451, line 11, *for* '(Plate 20, fig. 3; ......)' *read* 'Plate 19, fig. 3; ....).'

Page 494, line 21, *for* 'diopsid' *read* 'diopside.'

Page 502. In analysis II (35/292), BaO, *for* '0·08' *read* '0·02.'

Page 508. In analysis VIII (39/25-26), BaO, *for* '0·16' *read* '0·15.'

Page 509. Footnote XII, *for* 'Lataull' *read* 'Latauli.'

Page 515, line 3, *for* 'TiO_3' *read* 'TiO_2.'

Page 520. In column XV, for '34/499' *read* '34/449.'

Page 520. Column XVI, Orthoclase, *for* '3·39' *read* '3·89.'

ERRATA.

RECORDS, GEOL. SURV. IND., Vol. LXVI, Part 1.

Page 27, line 3, *for* 'Proteus' *read* 'Proetus.'

Page 72. In marginal heading under Sulphur, *for* 'Shahpur district, Punjab' *read* 'Attock district, Punjab.'

Page 96, line 31, *for* 'Namyao' *read* 'Namyau.'

Page 96, line 38, *for* 'Namyao' *read* 'Namyau.'

Page 97, line 3, *for* 'Namyao' *read* 'Namyau.'

MGIPC—M—VIII-4-5—21-1-33—800.

RECORDS

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NOTES ON SOME LOWER PALAEOZOIC FOSSILS FROM THE SOUTHERN SHAN STATES. BY F. R. COWPER REED, SC.D., F.G.S. (With Plate 3.)

A. ORDOVICIAN.

Locality (1) Bawzaing.

A small collection of fossils was recently made by Dr. Coggin Brown from Bawzaing (20°57′ : 96°51′), most of which were obtained from 'argillaceous silt-stones' or fine-grained flaggy sandstones which are stated to be intercalated with argillaceous dolomitic limestones yielding occasionally large specimens of a 'chambered cephalopod' and a 'large coiled euomphaloid gasteropod'. The fauna of the silt-stones contains a new assemblage of species, but only one species (*Orthis emancipata*, sp. nov.) is abundant and well characterised, the others being represented by single and mostly poor specimens.

LIST OF SPECIES.

Orthis (*Dalmanella*) *emancipata*, sp. nov.
Lophospira cf. *alternans*, Koken.
,, cf. *elevata*, Ulr. and Scof.
Helicotoma cf. *tamurai*, Kob.
,, cf. *planulatoides* Ulr.
Cyrtolites cf. *nodosus*, Salt.

Hyolithes ? sp.
Cycloceras ? sp.
Ogygites cf. *yunnanensis*, Reed.
Crinoidal remains.

The few specimens from Siderite Hill, Bawzaing, seem to indicate a slightly different Ordovician horizon, none of the species being identical; they are, therefore, described separately.

NOTES ON THE FOSSILS.

Orthis (Dalmanella) emancipata, sp. nov.

(Pl. 3, figs. 7-14.)

Shell plano-convex, shallow, semi-elliptical to subquadrate, as wide as long; hinge-line straight, nearly or quite equal to maximum width of shell; cardinal angles sub-rectangular, or slightly obtuse. Pedicle-valve gently convex, subcarinate, being most elevated along median line; beak small, not much raised above hinge-line, slightly incurved; hinge-area triangular, moderate, inclined or nearly in plane of valve. Interior with small, short, sub-rhomboidal, rounded, well-circumscribed, sunken muscle-scar about one-fifth to one-sixth the length of valve, nearly as wide as long, and composed of pair of very faintly indicated, triangular diductors enclosing shorter, narrow adductors; teeth short, stout; pair of weak, narrow, elongated, vascular sinuses diverging from sides of muscle-scar at about 60°; weak, submarginal, concentric, internal thickening of shell curving in near cardinal angles. Brachial valve flattened or slightly concave, with more or less marked, weak median sinus; beak very small; hinge-area narrow, nearly at right angles to valve. Interior with short, stout crura diverging at about 110°; cardinal process not preserved; muscle-scars very faintly marked; strong submarginal, concentric thickening, more prominent than in other valve. Surface of both valves covered with numerous fine, sharp, equidistant, angular riblets, regular and mostly equidistant, curving back slightly on each side, numbering in all 60-80 on margin, of which about half the number are primaries, the others (sometimes two to three in number), arising by intercalation at one-third to one-fourth their length. A minute, close, linear nodulation runs along the summit of each rib, and a delicate concentric striation covers the whole surface of both valves. Internally the ribbing shows distinctly,

and is especially strong towards the margins. Shell substance punctate ?

Dimensions.

Length	7—10 mm.
Width	9—11 mm.

Remarks.—This small species occurs abundantly in the collection as internal casts or impressions of the exterior of both valves, but few of them are perfect and the state of preservation renders it rather uncertain if the shell is punctate. It seems referable to the subgenus *Dalmanella*, Hall, as re-defined by Kozlowski [1] rather than to *Pionodema*, Foerste, as re-defined by Cooper [2], or to either of his new subgenera *Doleroides* or *Mimella*. But it may possibly represent a new subgenus. The specific affinities appear to be with *Orthis nodulosa*, Lindstr.[3]. of the Trinucleus Shales of Sweden rather than with *O. argentea*, His.[4], because of the minute nodulation of the ribs, though the style of ribbing and outline are closely similar to the latter, especially resembling Wiman's figures of the species from the Leptæna Limestone. The shell from the Hwe Mawng, beds previously described by the present author as *O. testudinaria* var. *shanensis* [5], is distinguishable by the forked muscle scar in the pedicle-valve and by the absence of the internal submarginal ridge as well as by the want of nodulation of the ribs. The ribbing and shape of certain American species, such as *O.* (*D.*) *resupinata*, Raymond[6] (non Martin), *O.* (*D.*) *rogata*, Sardeson,[7] and *O.* (*D.*) *emacerata*, Hall,[8] and its varieties may also be compared, but we may doubt if they are truly allied.

Lophospira cf. *alternans*, Koken.

The basal and next succeeding whorl of a pleurotomarioid shell, which are preserved in the collection, indicate a low conical subtrochiform shell with an apical angle of 90°—100°. The apical surface of the basal whorl is broad and flattened, sloping down to

[1] Kozlowski, *Brach. Gothl. Pod. Pol., Palaeont. Polonica*, I, p. 58, (1929).
[2] Cooper, *Journ. Palaeont.*, IV, No. 4, pp. 369-382; Pls. 35-37, (1930).
[3] Lindstrom, Fragm. Silur, p. 26; Pl. XIV, figs. 10-11*a*, (1880).
[4] Lindstrom, *op. cit.*, p. 26; Pl. XIV, figs. 12-15; Wiman, *Arkiv. f. Zool.*, Bd. 3, No. 24, p. 9, Pl. 1, figs. 20-21, (1907); Marr and Roberts, *Quart. Journ. Geol. Soc.*, XLI, p. 478, (1885).
[5] Reed, *Pal. Ind.*, *N. S.*, Vol. VI, Mem. No. 1, p. 9; Pl. II, figs. 6-11, (1925).
[6] Raymond, *Mus. Bull. Geol. Surv. Can.*, No. 31, p. 16; Pl. V, figs. 7-10, (1921).
[7] Sardeson, *Bull. Minnesota Acad. Nat. Sci.*, 3, p. 331; Pl. V, figs. 1-4, (1892).
[8] Hall and Clarke, Palæont., New York, Vol. VIII, pt. 1, pp. 207, 224; Pl. 5-C, figs. 1, 2, (1892); Foerste, *Bull. Denison Univ.*, No. XIV, p. 321; Pl. VII, fig. 1, (1909).

the angular periphery which carries on its upper edge the slit-band. Below the slit-band, the outer rounded face of the whorl is somewhat flattened and marked off from the high base by a faint, but sharp, narrow, revolving lira (keel), the base of this whorl being gently convex. The slit-band is of moderate width, concave and has sharp edges. The spire, is low and apparently only about half the height of the basal whorl. The small second whorl, which is only partly preserved, has the slit-band situated a little above the suture-line. Probably the rest of the spire was composed of 2—3 more whorls, and we may estimate the total height of the shell at about 22 mm. and the diameter of the basal whorl at about 15 mm.

Remarks.—As regards its affinities and generic position, we must put it in *Lophospira* rather than in *Clathrospira*, which does not have any revolving keel below the band on the basal whorl. But some examples of *Cl. subconica* (Hall)[1] from the Trenton, bear otherwise a close resemblance. The European species *L. alternans*, Koken,[2] *L. subalata*, Koken,[3] and *L. mickwitzi*, Koken,[4] from the Baltic Ordovician, seem to be allied species, but we may also compare the variety of *L. bantatsuense*, Koh,[5] from the Ordovician of Korea and *L. morrisi*, Grabau,[6] from the Ordovician of Chihli, China. A shell from the Pulaski drift, near Trenton, New York, which was first recorded as *Lophospira tropidophora*, Meek, but subsequently described by Ruedemann [7] as a new species under the name *Eotomaria pagoda*, seems to bear a considerable resemblance to our shell. It should be mentioned that Koken and Perner (*op. cit.*) consider *Lophospira*, Whitfield, to be a synonym of *Worthenia*, De Kon., which was founded on a Carboniferous species, but the former generic name is used by most authors for Lower Palæozoic species.

Lophospira cf. *elevata*, Ulrich and Scofield.

The imperfect internal cast of the two lowest whorls of a species of *Lophospira* seems to belong to a shell which may be compared

[1] Foerste, *Mem. Geol. Surv. Can.*, p. 210; Pl. XXXIV, fig. 12, (1924).
[2] Koken and Perner, *Mem. Acad. Sci. Russ.*, Vol. XXXVII, No. 1, p. 157; Pl. XXIX, fig. 10; text-fig. 31, (1925).
[3] *Ibid.*, p. 158; Pl. XXIX, fig. 16; text-fig. 32.
[4] *Ibid*, p. 159; Pl. XXVIII, fig. 20; Pl. XXIX, fig. 20; text-fig. 33.
[5] Kobayashi, *Japanese Journ. Geol. Geogr.*, Vol. VII, Nos. 3-4, p. 88; Pl. IX, fig. 5, (1930).
[6] Grabau, *Palæont. Sinica*, Ser. B, Vol. I, fasc. 1, p. 25; Pl. III, figs. 1, 2*a*, *b*, (1922).
[7] Ruedemann, *Bull. New York State Mus.*, No. 272, p. 72; Pl. IX, figs. 6-8, (1926).

with *L. elevata*, Ulr. and Scof.,[1] of the Trenton group. *L. pagoda* (Salter)[2] from the Central Himalayas, may also be allied. Our specimen has a sharply conical shape with a much smaller apical angle (about 45°—60°) than the previously-described species from Bawzaing; the suture-line is oblique, the whorls are subcentrally angulated, with the prominent periphery bearing the slit-band on it or just above it. No details can, however, be made out.

Helicotoma cf. *tamurai*, Kobayashi.

The impression of the apical surface and parts of the sides of a small gastropod measuring 8 mm. in diameter may be referred to the genus *Helicotoma.* It is coiled into a nearly flat spiral of 4—5 whorls which are subquadrate in cross-section and rise steeply in successive low steps to the apex, each having a rounded, steep, outer face meeting the broad, flattened, apical surface nearly at right angles and elevated along the periphery into a low keel. But the outer face is not well preserved in our specimens. The apex of the spire only rises a little above the level of the outer whorl, and the apical surface of each whorl is nearly horizontal, but slopes inwards a little to the suture. The keel on the outer whorl is submarginal. This shell resembles *H. superba*, Koken,[3] and *H. brocki*, Foerste[4] of the Black River group, Minnesota, and the Richmond formation of Georgian Bay, Ontario,[5] rather than any species of *Raphistoma*, though it is somewhat like *R. scalare*, Koken[6] of Stage C of the Baltic Ordovician. But we may particularly compare *H. tamurai*, Kobayashi,[7] from the Ordovician of Korea. The genus *Helicotoma*, Salter, is considered by Koken and Perner[8] to lie between *Raphistoma* and *Ophileta*.

Helicotoma cf. *planulatoides*, Ulrich.

On another piece of rock the imperfect impression of part of the spire of another species of *Helicotoma* is seen, with broken

[1] Ulrich and Scofield, Final Rept., Geol. Nat. Hist. Surv. Minnesota, Palaeont., Vol. 11, pt. 2, p. 977; Pl. LXXIII, figs. 11-14, (1897).

[2] Reed, *Pal. Ind.*, Ser. XV, Himal. Foss., Vol. VII, Mem. No. 2, p. 61; Pl. X, fig. 12, (1912).

[3] Koken and Perner, *op. cit.*, p. 119; Pl. XV, figs. 13-15.

[4] Foerste, *Bull. Scient. Lab. Denison Univ.*, Vol. XVII; Pl. X, fig. 11: Pl. XI, fig. 3, (1912).

[5] Foerste, *Mem. Geol. Surv. Can.*, No. 138, p. 216; Pl. XXXIV, figs. 23*a*, *b*, (1924).

[6] Koken and Perner, *op. cit.*, p. 84; Pl. VII, fig. 2.

[7] Kobayashi, *Japanese Journ. Geol. Geogr.*, Vol. VII, Nos. 3-4, p. 95; Pl. XI, figs. 4*a*, *b*, (1930).

[8] Koken and Perner, *op. cit.*, p. 117.

fragments of parts of other shells of the same species. The apical surface of each whorl is slightly concave and is marked with oblique, slightly curved, transverse, thin, equidistant, squamose lines; the outer edge is raised as in the other species, and the whorls ascend in similar successive steps, forming a very low spire; the outer face is steep, but none of the specimens are well enough preserved to decide the specific identity. *H. planulatoides*, Ulrich,[1] from the Black River formation, is specially comparable, for it has similar transverse, squamose lines on the upper surface of the whorls and its other characters are apparently identical. *H. tennesseensis*, Safford,[2] from the Stones River group, is also perhaps allied. We cannot see if there are any revolving lines on the body whorl as in *H. planulata*, Salter,[3] and in the previously mentioned *H. brocki*, Foerste,[4] both of which come from the Upper Ordovician of Canada and the United States.

Cyrtolites aff. *nodosus* (Salter).

An imperfect specimen of a species of *Cyrtolites* shows the right-hand side and part of the dorsum of the last whorl of the shell. It consists of a slightly coiled cornucopia, the whorls apparently being only just in contact, and the shell expands rather rapidly to the mouth. In transverse section it is broadly sublanceolate, the dorsum being subcarinate. The whorls are crossed obliquely by strong, widely spaced, continuous, subangular, narrow ridges which curve back to the dorsum, meeting in a sharp V; the interspaces are broad and gently concave. Any finer ornamentation which may have been originally present is not preserved, and the inner whorls are hidden in the matrix. In height, the shell seems to have been about 12 mm. The affinities are with *C. nodosus* (Salt.)[5] of the British Bala series and with *C. thraivensis*, Reed,[6] of the Drummuck group, Girvan, the variety of *C. nodosus* termed *llandoveriana*[7] bearing a close resemblance. *C. ornatus*, Conr.,[8] from he Richmond formation of America, is also closely allied.

[1] Ulrich and Scofield, *op. cit.*, p. 1034; Pl. LXXIV, fig. 28; Foerste, *Mem. Geol. Surv. Can.*, No. 138; Pl. XXXIV, fig. 22, (1924).

[2] Ulrich and Scofield, *op. cit.*, p. 1034; Pl. LXXIV, figs. 20-24.

[3] *Ibid*, p. 1033; Pl. LXXIV, figs. 15-17.

[4] Foerste, *Bull. Denison Univ.*, No. 17, p. 137; Pl. X, fig. 11, (1912); Pl. XI, fig. 3, (1912); *Mem. Geol. Surv. Can.*, No. 138, p. 216; Pl. XXXIV, figs. 23*a*, *b*, (1924).

[5] Reed, Ordov. and Silur. Bellerophontacea (*Palaeont. Soc.*), pt. 1, p. 25; Pl. V, figs. 1-2*a*, (1920).

[6] *Ibid.*, p. 26; Pl. V, figs. 7-10.

[7] *Ibid.*, p. 26; Pl. V, figs. 3-6.

[8] Ulrich and Scofield, *op. cit.*, p. 860; Pl. LXII, figs. 27-29.

Hyolithes ? sp.

A fragment of a compressed, conical, gently tapering, smooth shell with an elliptical section, and with the one side which is exposed showing a sharp line at the lateral junction of the dorsal and ventral faces may probably be referred to some species of *Hyolithes*. The specimen is broken across transversely, but only a piece 5—6 mm. in length is exposed; the opposite faces seem to have the same convexity, no flattening of one face being observable. The major and minor diameters of the cross section are respectively 7 mm. and 5 mm. No ornamentation of the surface is visible.

Cycloceras sp.

A fragment of a slender, nearly straight, cylindrical cephalopod, measuring rather more than 50 mm. in length and 6 mm. in diameter, is probably referable to the genus *Cycloceras* rather than to *Protocycloceras* or *Spyroceras*. It seems to have been subelliptical in section, but only a portion of the circumference (the dorsum ?) is exposed, the rest being hidden in the matrix. The rate of tapering seems to be very slow. It is annulated at almost equal intervals by narrow prominent rounded rings set apart mostly at more than half its diameter, and they seem to be slightly oblique to the axis, but we cannot see if they undulate. There are about six annulations in a length of 14 mm. The interspaces are concave and wide, being 3—4 times as wide as the rings. No septa or siphuncle are visible, but the exterior is seen to be ornamented with very fine, concentric striae which are only preserved in some of the interspaces. A general granulation is also present, and the minute granules seem to be arranged in rather widely spaced, longitudinal lines, but this is somewhat doubtful.

We were at first inclined to compare our specimen with *Orthoceras* (*Protocycloceras* ?) *deprati*, Reed,[1] from Shihtien, Yunnan, no ornamentation was visible on that species and the annulations are more oblique to the axis. Kobayashi [2] has recorded *Pr. deprati* from the Ordovician of Corea. We may best refer our shell to *Cycloceras* on the strength of its resemblance to *Cycloceras undulostriatum* (Hall) as re-defined by Foerste [3] from the Trenton

[1] Reed, *Pal. Ind., N. S.*, Vol. VI, Mem. No. 3, p. 33; Pl. V, figs. 15, 15*a*, *b*, (1917).
[2] Kobayashi, *Japanese Journ. Geol. Geogr.*, Vol. V, No. 4, p. 184; Pl. XIX, fig. 5, (1926-27).
[3] Foerste, *Bull. Denison Univ. Scient. Lab.*, Vol. XXIII, p. 176; Pl. XI, figs. 1-A—D, 1928).

limestone. The Chinese species *Cycloceras kawasakii*, Kob.,[1] seems also to be allied to our shell.

Ogygites cf. *yunnanensis*, Reed.

The broken impression of the lower surface of part of a large head-shield of a trilobite, resembling the species *Ogygites yunnanensis*, Reed,[2] from Yunnan, occurs on one of the slabs of rock with numerous examples of *Orthis emancipata*. We can see the outer edge and part of the posterior edge of one free cheek, the outline of the large eye and faint, concentric, subequidistant lines on the inferior surface, but the genal spine is broken off near the base. The head-shield of this individual must have measured, when perfect, at least 65 mm. in length. *O. birmanicus*, Reed,[3] from the Hwe Mawng beds of the Northern Shan States, which is closely allied to the Yunnan species, has fewer concentric striæ on the inferior surface of the head-shield, and thus seems less like our present fragmentary specimen. On the same slab as this large free cheek, there is a much smaller free cheek showing the upper surface, the eye, and the outer and inner margins of the cheek with the facial suture having the same course and the outer margin with the same flattened border as in *O. yunnanensis*. The genal angle is missing. Patte[4] has recorded from Tonkin a fragmentary specimen which he compares with *O. birmanicus*.

Crinoidal remains.

A number of small, slender, cylindrical, straight stems of approximately the same size and consisting of equal or nearly equal joints, with a diameter about 1½ times their thickness, are scattered about on the surface of one slab of rock from Bawzaing, containing a few specimens of *Orthis emancipata*. In places, the joints are detached and show their articulating faces. The central canal is very large and circular, and the narrow rim surrounding it has an outer row of short, marginal crenulations, 30—36 in number on a joint of average size. In one fragment of a stem, measuring 13·5 mm. in length and 1·7 mm. in diameter, there are 18 joints; in

[1] Kobayashi, *Japanese Journ. Geol. Geogr.*, Vol. VII, Nos. 3, 4, p. 84; Pl. VIII, figs. 3*a*, 3*b*, (1930).

[2] Reed, *Pal. Ind.*, *N. S.*, Vol. VI, Mem. No. 3, p. 42; Pl. VI, figs. 12-14; Pl. VII, figs. 1-8, (1917).

[3] Reed, *op. cit.*, Mem No. 1, p. 30; Pl. V, figs. 15-18; Pl. VI, figs. 1-4, (1915).

[4] Patte, *Bull. Serv. Geol. Indo-Chine*, Vol. XV, fasc. 1, p. 45; Pl. I, fig. 11, (1926).

another, 10 mm. in length and 1·6 mm. in diameter, there are 15 joints. Occasionally, there is a blunt prominence on the periphery of some of the joints, but this is rare and the stems are usually smooth. It is impossible to determine the genus of these isolated stems, but more than one species is represented.

Locality (1*a*) Siderite Hill, Bawzaing.

One piece of rock from this locality contains many fragmentary joints and stems of crinoids in the state of casts or impressions, and one internal cast of the pedicle-valve referable to *Orthis praetor*, Reed,[1] which occurs in the Ordovician of Yunnan, showing the characteristic small, subquadrate muscle-scar. There is also the impression of the exterior of two brachial valves which are bilobed by a rather sharp, deep, narrow, median sinus increasing in width anteriorly and bearing numerous, close, regular, equal, radial, rather thick, thread-like riblets increasing in number by intercalation to about 100—110 on the margin and curving back gently on each side of the median sinus. The valves are semi-elliptical in shape, about twice as wide as long and have rectangular cardinal angles. They suggest a comparison with *Orthis* (*Harknessella*) *vespertilio*, Sow.,[2] or one of the allied species described by Bancroft.[3] There is also a minute, somewhat imperfect head-shield of a species of *Pliomera*, which does not seem to be either *Pl. insangensis*, Reed, from the Northern Shan States, or *Pl. martellii*, Reed,[4] from Yunnan, but it is too poorly preserved to describe or to decide its precise affinities.

But we may certainly consider the age of the rock to be Ordovician.

Locality (1*b*) Bawzaing and Pennebin.

In the limestones, stated by Dr. Coggin Brown to be interbedded with the silt-stones containing the brachiopod *Orthis* (*Dalmanella*) *emancipata*, etc., it is mentioned by him that there are occasionally large specimens of '*Orthoceras* sp.' and a coiled, euomphaloid

[1] Reed, *Pal. Ind., N. S.*, Vol. VI, Mem. No. 3, p. 21; Pl. IV, figs. 9-12, (1917).
[2] Davidson, *Mon. Brit. Foss. Brach.*, No. III, p. 236; Pl. XXX, figs. 11-21.
[3] Bancroft, *Mem. Proc. Lit. Phil. Soc. Manchester*, Vol. 72, No. 12, p. 190; Pl. II, figs. 13-16, (1928).
[4] Reed, *op. cit.*, p. 55; Pl. VIII, figs. 15, 16, (1917).

gastropod. The two fragments of a cephalopod which he has sent me are not generically determinable, only the weathered edges of a series of rather closely set, oblique ? septa being visible. The third and larger block of limestone (marked 109) contains sections of the gastropod, 30—35 mm. in diameter, but it is impossible to say if it belongs to *Euomphalus*, *Ophileta* or *Maclurites*. Another piece shows some smaller, weathered, discoidal gastropods on the surface, but they are not determinable. A small piece of limestone from Pennebin, a locality further south, contains small, spherical organisms or bodies which weather out on the surface and recall foraminifera, but microsections show no recognisable structure.

Locality (2) Panghkaw.

NOTES ON THE FOSSILS.

Pliomera (*Encrinurella*) *insangensis*, Reed.

A portion of the thorax of a partially enrolled specimen showing 7—8 segments, and the impression of the exterior of same, may without hesitation be referred to this species [1] which occurs in the lithologically similar Hwe Mawng beds of the Northern Shan States, as well as in the Naungkangyi beds.[2]

Caryocrinus ? sp.

Two small plates of a cystidean of a pentagonal shield-shape may probably be referred to this genus.

Hyolithes ? sp.

A fragmentary, apical end of probably some species of *Hyolithes* is recognisable on another piece of rock.

Conclusions.—The evidence afforded by these few specimens is sufficient to indicate that the age of the bed corresponds with that of the Ordovician Upper Naungkangyi or Hwe Mawng beds of the Northern Shan States.

[1] Reed, *op. cit.*, Vol. VI, Mem. No. 1, p. 50; Pl. VIII, figs. 15-21, (1915).
[2] Reed, *op. cit.*, Vol. II, Mem. No. 3, p. 74; Pl. V, figs. 19-25, (1906).

Locality (3) Yeosin.

A considerable series of fossils was collected by Dr. Coggin Brown from the so-called Pindaya beds of this locality, but only a few of the specimens are in a good state of preservation, most of them being in the condition of imperfect internal casts or external impressions.

LIST OF SPECIES.

Orthis cf. *irravadica*, Reed.
  ,, (*Nicolella* ?) *praetor*, Reed.
  ,, (*Dinorthis* ?) sp.
  ,, (*Glyptorthis*) cf. *lamellosa*, Twenh.
Ptychoglyptus shanensis, sp. nov.
Yeosinella consignata, gen. et sp. nov.
Leptelloidea yeosinensis, sp. nov.
Sowerbyella ? aff. *youngiana* (Dav.).
  ,, ? cf. *ledetensis* (Reed).
Christiania cf. *tenuicincta*, McCoy.
Petroria cf. *rugosa*, Wilson.
Camarella sp.
Protocrisina cf. *ulrichi*, Bassler.
Rhinidictya cf. *nitidula* (Billings).
  ,, cf. *mutabilis*, Ulrich.
Pachydictya sp.
Ptilodictya sp.
Favosites ? sp.
Batostoma sp.
Caryocrinus cf. *turbo*, Bather.
  ,, sp., a.
  ,, sp., b.
Crinoid stem joints.
Illaenus sp.
Primitia sp.
Dictyonema ? sp.

NOTES ON THE FOSSILS.

Orthis cf. *irravadica*, Reed.

This species[1] was founded on specimens from the Naugkangyi beds in the Northern Shan States and is somewhat variable. It

[1] Reed, *Pal. Ind.*, N. S., Vol. II, Mem. No. 3, p. 52; Pl. IV, figs. 15-22, (1906).

was compared with *O. moneta*, Eichw., and especially with the variety figured by Wysogorski which Opik[1] also figures from Stage C 2 in Esthonia and places in the subgenus *Nicolella*. But we may better compare *O. lyckholmiensis*, Wiman,[2] from the Lyckholm bed and from the Leptaena Limestone of Sweden. There are some imperfect specimens in the collection from Yeosin which may be compared with *O. irravadica*, but they are too poorly preserved for a precise determination.

Orthis (*Nicolella* ?) *praetor*, Reed.

This species[3], which was established for a form occurring in the Ordovician of Pupiao in Southern Yunnan, is represented by several imperfect impressions and casts from Yeosin. It bears a certain resemblance to *Orthis* (*Scenidium*) *compta*, Salter,[4] from the Central Himalayas, but may more probably be referred to the subgenus *Nicolella* and be considered allied to *O. actoniae*, Sow., especially resembling the variety *asteroidea*[5] from Girvan and some shells figured by Opik[6] as *Nicolella* sp. from Stage C 2 in Esthonia and by Lindstrom[7] from Sweden. It does not seem allied to *O. irravadica* as was previously suggested, and probably belongs to a different group or subgenus.

Orthis (*Dinorthis* ?) sp.

The impression of the greater part of a large, flattened or very slightly convex, subcircular or semielliptical valve occurring in the collection from Yeosin represents a shell of about 30 mm. in length. The hinge line and umbonal characters are not preserved, but the surface bears a number of regular, straight, narrow, rounded ribs of equal size, separated by narrow, rounded, deep interspaces nearly equal in size to the ribs, and all covered with a fine, close, concentric striation. Near the middle of the valve, a few of the ribs bifurcate towards the margin, but all the rest are simple and must have numbered about 50—60 on the complete valve. Probably we may

[1] Opik, Brach. Protrem. Estl. Ordov. Kukruse-Stufe, *Act. Comm. Univ. Tartuensis*, A., XVII, 1, p. 98 ; Pl. V, figs. 45, 46, (1930).
[2] Wiman, *Arkiv. f. Zool.*, Bd. 3, No. 24, p. 8 ; Pl. 2, figs. 9-12*a*, (1907).
[3] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 3, p. 21 ; Pl. IV, figs. 9-12, (1917).
[4] Reed, *Ibid*, Ser. XV, Himal. Foss., Vol. VII, Mem. No. 2, p. 29 ; Pl. VI, figs. 6-9, (1912).
[5] Reed, *Trans. Roy. Soc. Edinb.*, LI, pt. IV, p. 861 ; Pl. X, figs. 28-35, (1917).
[6] Opik, *op. cit.*, p. 97 ; Pl. IV, fig. 43 ; p. 98 ; Pl. IV, fig. 44,
[7] Lindstrom, Fragm. Silur, p. 27 ; Pl. XIV, figs. 4-9, (1880).

refer this shell to some species of *Dinorthis* on the strength of the ribbing and outline, and *O.* (*D.*) *porcata*, McCoy, as figured from the Upper Bala of Girvan [1] may be compared; but *O.* (*D.*) *porcata* var. *birmanica*, Reed.[2] from the Upper Naungkangyi beds is probably identical. Amongst American species, we may mention *O.* (*D.*) *carleyi*, Hall.[3] of the Richmond group, which seems to be very close to the British *O.* (*D.*) *retrorsa*, Salter.

Orthis (*Glyptorthis*) cf. *lamellosa*, Twenhofel.

The impression of the greater part of a brachial valve of a small brachiopod shows the shape and the coarse. angular ribbing with the well marked, regular lamellation crossing the surface, which is present in *Orthis ? lamellosa*, Twenhofel,[4] and *O. keisleyensis*, Reed,[5] the former occurring in the Ordovician (Ellis Bay formation) of Anticosti Island and the latter in the Keisley limestone of England. There are about 12 ribs in our specimen from Yeosin, the two median ones lying in a weak sinus. No other characters are visible. *Orthis* (*Glyptorthis*) *lapworthi*, Dav.,[6] which occurs in the Balclatchie group of Girvan, is another allied species, as far as can be judged from external characters, but its reference to *Hebertella* can no longer be maintained and Cooper [7] has recently described an allied species from Percé, Quebec, as *Glyptorthis sublamellosa*. All of these species resemble *O. bouchardi*, Dav., from the Silurian.

Yeosinella consignata, gen. et sp. nov.

(Pl. 3, figs. 1, 1*a*, 2.)

Shell transversely fusiform, alate, widest along hinge-line, with acutely pointed and more or less produced, cardinal angles. Pedicle-valve moderately convex, most so in middle; beak small, somewhat incurved. Interior unknown. Brachial valve somewhat flattened, gently bilobed by broad, shallow, rounded sinus widening

[1] Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. 4, p. 838; Pl. VII, figs. 7-12, (1917).
[2] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 1, p. 10; Pl. II, figs. 12, 13, (1915).
[3] Foerste, *Journ. Cincinnati Soc. Nat. Hist.*, Vol. XXII, No. 2, pp. 47-51; Pl. II, figs. 3-A—E.
[4] Twenhofel, *Mus. Bull. Geol. Surv. Can.*, No. 3, p. 24; Pl. I, figs. 1-3, (1914); also *Mem. Geol. Surv. Can.*, No. 15*a*, p. 175; Pl. XV, figs. 7-9, (1928).
[5] Reed, *Quart. Journ. Geol. Soc.*, Vol. LIII, p. 69, (1897).
[6] Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. IV, p. 843; Pl. VIII, figs. 8-14, ? 15-17 (1917).
[7] Cooper, *Amer. Journ. Sci.*, Vol. XX, p. 265; Pl. I, figs. 21-22, (1930).

rather rapidly towards the front; hinge area narrow, triangular, inclined; interior of valve with thickened, ill-defined hinge-plate bearing broad, triangular, low, sessile cardinal process composed of pair of adjacent, parallel, sublanceolate lobes facing inwards and in plane of valve; crura short, stout, triangular, divergent, making an angle of about 30° with hinge-line, forming inner walls of deep, short, dental sockets with their inner face corrugated by 4—5 strong, transverse grooves. Muscle-scars indistinct. Surface of valves ornamented with 20—22 simple, thick, straight, radiating, rounded ribs of equal size, separated by narrower, sharply rounded interspaces and crossed by regular, equidistant, concentric, closely placed, rather coarse lines. In internal casts, the ribs show distinctly over the whole interior of the shell and are especially strong and well marked near the margins. Shell-substance rather coarsely punctuate.

Dimensions.

Length	7 mm.
Width	17 mm.

Remarks.—This new species is represented by one good internal cast (A. 484)[1] and an external impression of a brachial valve (A. 484),[1] together with one imperfect impression of a pedicle-valve and a very poor internal cast of another brachial valve (A. 491)[2]. All are of approximately the same size. It is rather similar in outline and ribbing to the Wenlock species *Strophomena applanata*, Salter,[2] but it is doubtfully allied to it and we may better compare the imperfectly known '*Orthis*' *alata*, Sow.,[3] from the Llandeilo of Shropshire. It is probable that the so-called *Chonetes ? thebawensis*, Reed,[4] from the Naungkangyi beds of the Northern Shan States, which was founded on a single pedicle-valve, is allied to or even identical with our Yeosin shell. The bilobed cardinal process, the stout crura and teeth with transversely grooved faces, the bilobation of the brachial valve and coarsely punctate shell seem to make it necessary to refer our species to a new genus rather than to any other established one.

[1] Registered number in the fossil collections of the Burma Party, Geological Survey of India, Rangoon.

[2] Davidson, Mon. Foss. Brach., Vol. III, p. 308; Pl. XLIII, figs. 12-14.

[3] *Ibid*, p. 232; Pl. XXXIII, figs. 17-21.

[4] Reed, *Pal. Ind.*, N. S., Vol. II, Mem. No. 3, p. 57; Pl. V, fig. 16, (1906).

The external characters somewhat resemble *Orthis* (*Billingsella* ?) *laurentina*, Billings, from the Anticosti group,[1] as well as some species of *Scenidium*, especially *Sc. oelandicum* Wiman,[2] of the Leptæna Limestone and *Sc. anthonense*, Sardeson, of the Trenton,[3] but the internal characters are completely different. There is a greater resemblance to *Clitambonites* (Vellamo) *pyramidalis arcuatus*, Opik,[4] but we may greatly doubt if they are allied. The new genus may bear the name *Yeosinella.*

Ptychoglyptus shanensis, sp. nov.

(Pl. 3, fig. 15.)

Shell transversely semi-elliptical, widest along hinge-line, with acutely pointed cardinal angles. Pedicle-valve gently convex; brachial valve concave, closely appressed. Hinge-area of pedicle-valve triangular, of moderate width, steeply inclined. Surface of valves ornamented with 10—12 fine, straight, equidistant, linear radii with wide, flat interspaces between them occupied by transverse, broken, somewhat irregularly zigzag, narrow, rounded rugæ which are not continuous and in places are nodular.

Dimensions.

Length	c. 5 mm.
Width	c. 8 mm.

Remarks.—There is only one small specimen of this shell, but it shows the shape and ornamentation well. In ornamentation, it is especially like *Strophomena ruga*, Hume,[5] of the Ordovician of Great Slave Lake, Canada, and it also resembles *Leptæna julia* (Billings) from Anticosti,[6] but it undoubtedly belongs to the genus *Ptychoglyptus*, Willard, and is allied to *Pt. bellarugosus*, Cooper,[7] from the Upper Ordovician of the Percé area, Quebec. The transverse rugæ in our new species are much less regular and more broken

[1] Twenhofel, *Mem. Geol. Surv. Can.*, No. 154, p. 176; Pl. XV, figs. 17, 18 and references, (1928).
[2] Wiman, *Arkiv. f. Zool.*, Bd. 3, No. 24, p. 7; Pl. 1, figs. 5-11, (1907).
[3] Winchell and Schuchert, Lower Silur. Brach. Minnesota, *Geol. Nat. Hist Surv. Minnesota*, Vol. III, p. 381; Pl. XXX, figs. 20-23, (1893).
[4] Opik, *op. cit.*, p. 215; Pl. XIX, fig. 223.
[5] Hume, *Bull Geol. Surv. Can.*, No. 44, p. 63; Pl. XIII, figs. 4*a*, 4*b*, (1926).
[6] Twenhofel, *op. cit.*, p. 194; Pl. XXII, figs. 1-2, (1928).
[7] Cooper, *Amer. Journ. Sci.*, Vol. XX. p. 269; Pl. I, fig. 5, (1930).

than in this species or in *Pt. virginiensis*, Willard,[1] from the Holston limestone of Tennessee. It is not identical with *Stroph.* aff. *corrugatella*, Dav., from the Hwe Mawng beds,[2] which has many more radial riblets and lines and an altogether different shape, though the nodular rugæ give it a somewhat similar appearance.

Leptelloidea yeosinensis, sp. nov.

(Pl. 3, figs. 3-6.)

Shell transversely semi-elliptical, widest along hinge-line; cardinal angles slightly produced, acutely pointed. Brachial valve with narrow cardinal area, at right angles to plane of valve; interior with narrow, submarginal, concentric ridge and concave, visceral disk which has a sharp, elevated edge and is divided by a steeply rising broad, elongated, subtriangular, thick, median ridge widening anteriorly and extending in front of it; two pairs of adjacent, well-marked adductors are present on the disk, forming a pair of triangular, divergent, sunken scars, radially striated; crural plates short, strong, recurved, situated close to cardinal margin. Pedicle-valve gently convex; interior unknown. Surface of valves covered with rather thick, strong, rounded radii of which 8—10 are primaries but scarcely larger than the 3—4 secondaries which lie between them; a delicate close regular, concentric striation is present over all.

Dimensions.

Length	4 mm.
Width	8 mm.

Remarks.—This species is closely allied to *Leptelloidea llandeiloensis* (Dav. pars),[3] the interior of the brachial valve being almost identical in character with the one figured by Davidson and accepted by Jones[4] as the type. A shell which was considered to be allied to Davidson's species was figured and described by the author[5] from the Upper Naungkangyi beds in 1915, and is probably identical with our Yeosin species. The ribbing and ornamentation of

[1] Willard, *Bull. Mus. Comp. Zool.*, Vol. LXVIII, No. 6, p. 283; Pl. II, fig. 12, (1928).
[2] Reed, *Pal. Ind.*, Vol. VI, Mem. No. 1, p. 12; Pl. III, figs. 2, 2*a*, (1915).
[3] Davidson, Mon. Foss. Brach., Vol. V, Suppl., p. 171; Pl. XII, fig. 26 (Non. figs. 27-29); Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. IV, No. 26, p. 876; Pl. XIII, figs. 32-34; Pl. XIV, figs. 1-3, (1917).
[4] Jones, *Mem. Geol. Surv. Gr. Brit., Palæont.*, Vol. I, pt. 5, p. 477, (1928).
[5] Reed, *ibid.*, p. 13; Pl III, fig. 3, (1915).

our new form are distinctive features which easily mark it off from the British species.

Sowerbyella ? aff. *youngiana*, (Davidson).

There is one internal cast of a swollen, transversely subcircular, almost hemispherical pedicle-valve (A. 489) with a broad, incurved, overhanging beak and a hinge-line rather less than the width of the valve. The edges are somewhat broken, but on one side a marginal thickening is seen. A pair of longitudinal, parallel, vascular ? ridges run forward nearly to the anterior margin and leave a broad, smooth, median space between them marked with fine, longitudinal striæ, and in the anterior half there is a single, median, strongly margined, vascular ridge as wide as the members of the pair; on the lateral slopes of the valve there is a shorter, parallel, vascular ridge with traces of another nearer the hinge-line.

This shell most resembles *Leptæna youngiana*, Dav.[1] from the Craighead limestone of Girvan, which the present author[2] put with a query in the genus *Plectambonites*, but Jones[3] has doubtfully referred to *Sowerbyella*, though he says it may belong to a new genus or subgenus. It seems more allied to *Christiania* than to any other genus, and the innermost pair of the so-called, vascular markings may be elongated muscle-scars.

Dimensions.

Length	9·0 mm.
Width	10·5 mm.

Sowerbyella ? cf. *ledetensis*, (Reed).

Two examples of a shell which is probably identical with *Leptaena* ? *ledetensis*, Reed,[4] of the Naungkangyi beds occur in the collection from Yeosin. The genus is probably *Sowerbyella*, and its previous comparison with *Leptaena rhomboidalis* was incorrect. We may better compare it with *Plectambonites himalensis* (Salter)[5] from the Central Himalayas.

[1] Davidson, *op. cit.*, Vol. III, pt. VII, p. 320; Pl. XLVII, figs. 19, 20, (1870).
[2] Reed, *op. cit.*, p. 889; Pl. XVI, figs. 14-18, (1917).
[3] Jones, *op. cit.*, p. 494, (1928).
[4] Reed, *op. cit.*, p. 34; Pl. IV, figs. 39-41, (1906).
[5] Reed, *Pal. Ind.*, Ser. XV, Himal. Foss., Vol. VII, Mem. No. 2, p. 48; Pl. IX, figs. 16-19, (1912).

Christiania cf. *tenuicincta* (McCoy).

The internal cast of a pedicle-valve measuring only 1·75 mm in length and about half as wide has the peculiar suboblong, strongly inflated shape of *Christiania tenuicincta* (McCoy)[1] with the steeply descending sides, short hinge-line and elongated, narrow, vascular channels of that species, which occurs in the Upper Bala of the British Isles, especially resembling the narrow, elongated form figured by Davidson (*op. cit.*, figs. 11, 12). The species has been recorded[2] from the Hwe Mawng beds. It is possible that more than one species has been included under this name, as it has been recorded from several horizons in the Ordovician and also from the Llandovery. We may also compare the species *Chr. dubia*, Cooper,[3] from the Ordovician of Percé, Quebec, and *Chr. trentonensis*, Rued.,[4] from the Trenton, with our Yeosin form.

Petroria cf. *rugosa*, Wilson ?

(Pl. 3, fig. 16.)

In 1926, A. E. Wilson[5] described and figured a new genus and species, allied to *Plectambonites* (*sens. extenso*) from the Upper Ordovician of British Columbia, under the name *Petroria rugosa*, of which one of the chief peculiarities is the concentric lamellation of the surface. There is a specimen of a pedicle-valve (A. 490) in the collection from Yeosin which shows this feature, though in a somewhat weathered condition, but otherwise it is clearly like *Plectambonites*. In shape and other characters, it more resembles Wilson's species than any other brachiopod. It measures 11·5 mm. in width and about 6·5 mm. in length.

Camarella sp.

The internal cast of a rounded, transversely subtriangular pedicle-valve of a shell which may be referred to the genus *Camarella* measures 8·5 mm. in width and 7 mm. in length. It is truncated in front and has a broad, shallow sinus holding three equal, rounded ribs; the lateral lobes carry 3—5 larger and stronger ribs which

[1] Davidson, Mon. Brit. Foss. Brach., Vol. III, pt. VII, p. 326; Pl. XLVII, figs. 7-13; Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. IV, p. 902; Pl. XVIII, fig. 10, (1917).

[2] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 1, p. 14, (1915).

[3] Cooper, *Amer. Journ. Sci.*, Vol. XX, p. 273; Pl. I, figs. 14-18, (1930).

[4] Ruedemann, *Bull. New York State Mus.*, No. 49, p. 21; Pl. II, figs. 2-6, (1901).

[5] Wilson, *Bull. Geol. Surv. Can.*, No. 44, p. 27; Pl. V, figs. 15-18, (1926).

are most prominent at the front, and the decrease in size towards the cardinal angles which are broadly rounded. There is a distinct, small, elongated spondylium and a median septum extending about half the length of the valve. This shell seems to resemble *Camarella volborthi* (Billings)[1] of the Black River and Trenton limestones and especially *C. bella* Fenton,[2] of the Plattin limestone of Missouri, but is less globose than the former, and is more like *C. thomsoni* (Dav.) of the Craighead limestone[3] and Keisley limestone.[4]

Protocrisina cf. *ulrichi*, Bassler.

A fragment of a zoarium measuring about 12 mm. in length and 8·5 mm. in width shows 10—11 sub-parallel, rather wavy branches of equal size, very rarely bifurcating, and bearing two rows of rather large zooecia, but it is not well enough preserved to make out any details. We may compare it with *Protocrisina ulrichi*, Bassler,[5] of the Kuckers shale, Esthonia. A species which is allied has been described by the present author from the Dufton shales of England as *Crisinella* [=*Protocrisina*] *wimani*.[6]

Rhinidictya cf. *mutabilis* (Ulrich).

Some of the imperfect and fragmentary casts (A. 486) of species of *Rhinidictya* resemble in many respects *Rh. mutabilis* (Ulrich)[7] and to a less extent *Rh. exigua* (Eichw.)[8] from the Ordovician (Trenton) of the United States and Russia. Our specimens of the type which is better comparable with the former species consits of flattened, ribbon-like branches about 2·5 mm. in diameter, which bifurcate occasionally at about 30°—45° and bear 5—7 longitudinal and diagonal rows of small, oval zooecia with rather thick walls which are granulose. The edges of the branches are smooth and without zooecia. The total length of the largest fragmentary zoarium from Yeosin is about 25—30 mm.

[1] Hall and Clarke, *Pal., New York*, VIII, Brach., pt. II, p. 219; Pl. LXII, figs. 11-18.
[2] Fenton, *Amer. Midland Naturalist*, Vol. XI, p. 133; Pl. III, figs. 1-12, (1928).
[3] Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. IV, p. 927; Pl. XXII, figs. 29-32, (1917).
[4] Reed, *Quart. Journ. Geol. Soc.*, Vol. LIII, p. 73, (1897).
[5] Bassler, *Bull. U. S. Nat. Mus.*, No. 77, p. 73; Pl. XII; and text-figs. 18a-c, (1911).
[6] Reed. *Geol. Mag.*, Dec. V, Vol. VII, p. 294; Pl. XXIII, figs. 1-3, (1910).
[7] Ulrich, *Geol. and Nat. Hist. Surv. Minnesota*, Vol. III, pt. I, p. 125; Pl. 6, figs. 1-6, 12, 13; Pl. 7, figs. 10-23, 25-28; Pl. 8, figs. 1-3, (1893). Bassler, *op. cit.*, No. 77, p. 132 text-figs. 56a-e, (1911).
[8] Eichwald, Leth. Ross., Vol. I, p. 392; Pl. XXVI, figs 11a, b, (1860) Bassler, *op cit.*, p. 133; text-figs. 57, 58, (1911).

Rhinidictya cf. *nitidula* (Billings).

Amongst the many other, poorly preserved portions of branches of species of *Rhinidictya*, there are some which may be compared with *Rh. nitidula* (Billings)[1] from Anticosti Island. But they are too imperfect for a precise determination.

Ptilodictya sp.

There is another bryozoan occurring at Yeosin which may be referred to the genus *Ptilodictya*, for the zooecia are oblong in shape, closely placed and arranged in 5—6 longitudinal rows on a flat, ribbon-like, straight, unbranched zoarium. Perhaps it is allied to *Pt. gladiola*, Billings.[2] The genus has been previously recorded from the Upper Naungkangyi and Hwe Mawng beds.[3]

Pachydictya sp.

Portions of the zoarium of some species of *Pachydictya* occur also at Yeosin. One flat frond about 6 mm. wide, bifurcating into rather narrower branches above, shows 5—6 subcircular, rather widely spaced zooecia having thick walls and arranged across its surface rather irregularly in diagonal rows. The interspaces are covered sparsely with small granules and pits (mesopores ?) and the margins of the branches are also granulated. *P. flabellum* (Leucht.)[4] may be allied.

Primitia sp.

Only a few imperfect, minute examples of this genus are preserved in the collection from Yeosin, and it is not possible to determine their specific reference.

Illaenus sp.

There is one imperfect head-shield (A. 488) of a species of *Illaenus* in the collection from Yeosin having the glabella and most of the left cheek as well as the anterior portion of the cranidium preserved. The head-shield is semi-elliptical in outline and convex, the anterior half in front of the glabella and the sides being

[1] Twenhofel, *Mem. Geol. Surv. Can.*, No. 154, p. 165; Pl. XIV, figs. 14, 15, (1928).
[2] Bassler, *op. cit.*, p. 114; text-fig. 43, (1911).
[3] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 1, p. 6, (1915).
[4] Bassler, *op. cit.*, p. 140; Pl. VIII, fig. 1; text-figs. 63, 64.

strongly arched down. The glabella, which has a slight independent convexity, is broad and more than half the width of the head-shield and rather less than half its length; it is defined by well-marked, axial furrows which are deepest at the base, nearly straight, converge slightly anteriorly and have their front ends scarcely everted. The fixed cheeks are narrow, about one-fourth the width of the glabella, and the eye is apparently situated at more than half its length and seems to have been small; the posterior branch of the facial suture runs back to cut the posterior margin of the head-shield at an angle of 75°—80°, while the anterior branch curves out widely. The surface ornamentation is not preserved.

Dimensions.

Length of cranidium	c. 21 mm.
Width of cranidium at base	c. 20 mm.
Length of glabella	14 mm.
Width of glabella	10 mm.

Affinities.—It is difficult to determine the relations of this fragmentary specimen, but *Illaenus linnarssoni*, Holm,[1] is perhaps allied.

Caryocrinus cf. *turbo*, Bather.

One hexagonal plate of the calyx of a species of *Caryocrinus* shows characters which suggest its comparison with *C. turbo*, Bather,[2] from the Naungkangyi beds of Sedaw. The tubercles are few and irregularly distributed.

Caryocrinus sp., a.

A regular, larger, pentagonal plate, measuring 14 mm. by 10·5 mm. and showing 2 demirhombs, has the tubercles on the surface more numerous than in the last mentioned form, and they are arranged in 1—4 straight lines of 4—6, forming a V shaped design between the radial ridges.

Caryocrinus sp., b.

A hexagonal, gently convex plate, measuring 16 mm. by 12·5 mm., has the spaces between the narrow radial ridges occupied by irregular, short, rounded, vermiculate rugæ and nodular swellings, and

[1] Holm, Rev., Ostbalt. Silur. Trilob. Abt., III, *Mem. Acad. Imper. Sci. St. Petersb.* Ser. VII, Vol. XXIII, No. 8, p. 146; Pl. X, figs. 10-23, (1886).
[2] Bather. in Reed, *Pal. Ind.*, N. S., Vol. II, Mem. No. 3, p. 30; Pl. II, figs. 8-12, (1906).

the whole surface is also sprinkled with minute granules. Bather (*op. cit.*) believes that the plates in *C. turbo* were originally 'rather coarsely rugose or vermiculate,' but the specimens with which he had to deal were all much worn on the surface.

Crinoid stem joints.

Portions of stems and isolated joints of a crinoid show that the stems were smooth and cylindrical with a large, five-rayed, central canal, the narrow arms of it reaching nearly to the periphery, and with the intervening areas radially and finely striated over their whole surface.

Another type of stem is pentagonal with projecting, narrow, annular rings at definite intervals.

A third type of stem has a large, subcircular canal with a marginal ring of coarse, radial grooves near the periphery.

Favosites ? sp.

A portion of a small disciform coral measuring about 20—25 mm. in diameter is preserved as a cast and impression on the back of the piece of rock (A. 490) containing *Petroria* cf. *rugosa*, Wilson. The basal, epitheoal plate is circular, flattened or slightly concave and marked with rather strong, concentric wrinkles. The corallites, which are only preserved as internal casts, have their sides exposed and consist of short cylindrical tubes of equal diameter, about 8—9 occurring in a space of 5 mm.; the middle tubes are the longest (about 2—3 mm.) as the surface of the corallum is gently convex; all are set at right angles to the epithecal plate and have rather thick walls, but they do not seem to be separated by a vesicular zone as in *Lyellia nummulosa*, Twenh.,[1] and *Pinacopora grayi*, Eth. and Nich.;[2] moreover, they seem to show small connecting pores as in *Favosites*, irregularly distributed on the walls, so that we may probably refer it to this genus.

Dictyonema ? sp.

Small portions of a reticulate hydrozoan ? with irregularly radiating, narrow branches forming rather large meshes of somewhat

[1] Twenhofel, *Mem. Geol. Surv. Can.*, No. 154, p. 135; Pl. V, figs. 1-5, (1928).

[2] Etheridge and Nicholson, Mon. Silur. Foss. Girvan, fasc. 1, p. 54; Pl. III, figs. 3-3$_f$, (1878).

unequal size and irregular rhomboidal shape, which measure 2—3 mm. in length and less in width, may possibly belong to some species of *Dictyonema*. No differentiated dissepiments can be detected, and the structure of the branches cannot be distinguished, but the whole appearance of the fossil is that of an irregularly retiform, flat expansion. The generic reference is doubtful, but it may be mentioned that Mansuy[1] has figured a doubtful example of the genus *Dictyonema* from the Lower Palæozoic (Ordovician ?) of Tonkin, which is somewhat like our fossil.

Incertae sedis.

There is one hollow impression of a body which seems to have had a transversely elliptical or semi-elliptical shape and a gentle convexity, but it is so distorted and broken that its original outline is uncertain. The ornamentation of the surface is well preserved and of a peculiar character, consisting of a series of somewhat undulating, concentric rows of closely placed, circular to subquadrangular pits of equal size over the outer marginal half, but the rows near the edge are composed of rather smaller pits. The rows are separated by about their own width and are mostly continuous, but here and there a shorter row is intercalated. The inner and middle part of the surface which is preserved is covered with larger circular or hexagonal pits closely but irregularly placed and not arranged in concentric rows, but a more regular, linear arrangement of smaller pits prevails near the straight, inner margin. Unfortunately, the edges of the whole impression are irregularly broken and imperfect, so that the true shape and outline of the organism are uncertain, but the left hand, anterior ? margin has a definite curve to which the rows of pits are concentric, and it is only from the course of the other parts of the rows that we conclude the true outline was transversely semi-elliptical. From the straight inner (? posterior) margin there are distinct traces of two very short, parallel, longitudinal, rounded grooves marking off a median, slightly more convex, subcylindrical area which suggests a glabella of a head-shield or the axial lobe of a pygidium of *Illaenus*. The basal corners of this 'head-shield' are imperfect, but it seems to have measured about 20 mm. in length and 30—35 mm. in

[1] Mansuy, *Mém. Serv. Géol. Indo-Chine*, Vol. III, fasc. 2, p. 59; Pl. VI, fig. 17; Pl. VII, fig. 1, (1914).

width, and the 'glabella' has a width of about 10 mm. But its true reference is problematical.

AGE OF THE FAUNA.

From the affinities of the new species here described and of those which are comparable or identical with established species from definite horizons elsewhere, we are led to conclude that this fauna is of Upper Ordovician age. It is, however, different from that of Bawzaing or Panghkaw, and contains very few species which can be identified with those known from the Lower or Upper Naungkangyi or Hwe Mawng beds of the Northern Shan States or the Ordovician of Yunnan.

Locality (4) Teinnan.

There are six fragments of fossils from the reddish, crushed limestone (so-called 'Orthoceras Limestone') of this locality. Three of them belong to the same shell and are described below. The others (A. 497, A. 498, A. 499) are indeterminable and too poor for description, but may belong to Orthoceracones. The rock is probably of Ordovician age.

NOTES ON THE FOSSILS.

Actinoceras sp.

One large orthoceracone, with part of both ends missing and broken into three pieces (A. 497), has the interior almost entirely filled with crystalline calcite and the internal structures and shell are quite obliterated, except in a few places where the septa are partly preserved and at the upper, weathered end where the siphuncle is seen in transverse section. The total length of the three fragments is about 180 mm., but when perfect, the shell must have been considerably longer. In shape it is straight and cylindrical; the diameter at the upper end is about 25 mm. and at the lower end about 15 mm., so that the rate of tapering is about 1 in 18. The exterior of the shell is not exposed, but was apparently smooth and without annulations or longitudinal ribs. The specimen is split longitudinally but excentrically. The septa are rather deeply concave and widely separated, being about half the diameter apart, and bend up more steeply on one side than on the other to meet

the wall at a very acute angle. The broken and weathered transverse, sub-circular section of the upper end of the shell shows the circular endosiphuncle, which is only one-seventh to one-eighth the diameter of the shell; it is somewhat excentric in position, and it is surrounded by a large outer nummuloidal encircling tube (siphuncle) with ribbed or frilled (?) exterior at a distance of about twice its diameter. From these characters, we may probably assign the specimen to the genus *Actinoceras* or one of its allies,[1] but the determination is doubtful. The septa are wider apart than in any of the species of *Actinoceras* described by Grabau [2] from the Ordovician of North China, and none of the species described by Kobayashi [3] from Corea and Manchuria seem to be closely allied. It may belong to the genus *Ormoceras*, and the wider separation of the septa and their apparent obliquity seem to resemble *O. oelandicum*, Troedsson,[4] from the Upper Red Orthoceras Limestone of the Island of Oeland and *O. holmi*, Troedsson,[5] from the Vaginatum limestone of Esthonia. However, on the whole, it appears to be more probably referable to some species of *Actinoceras* such as *A. bigsbyi* (Bronn) [6] and *A. saffordi*, Foerste and Teichert, of the American Ordovician.

Locality (5) Hill behind Taunggyi.

(K. 15. 124[7]).

A few specimens were collected by Sir Henry Hayden in 1911 from a locality thus described, but Dr. Coggin Brown informs me that he has not been able definitely to identify the locality. The horizon was recognised to be of Ordovician age, but the specimens have not previously been described and are of sufficient interest to warrant a few remarks, although they are

[1] Foerste, *Bull. Denison Univ. Scient. Lab.*, Vol. XXIV, pp. 192-209, (1929); *ibid.*, Vol. XXV, pp. 201-296; Pls. XXVII-LIX, (1930).

[2] Grabau, *Palaeont. Sinica*, Ser. B, Vol. I, fasc. 1, pp. 70-89; Pls. VII and VIII, (1922).

[3] Kobayashi, *Japanese Journ. Geol. Geogr.*, Vol. V, No. 4, pp. 191-202; Pls. XIX-XXII, (1926-27).

[4] Troedsson, Mid. and Up. Ordov. Faunas of Northern Greenland, *Medd. om Grønland.* LXXI, p. 105; Pl. LXI, fig. 1; Pl. LXII, fig. 4, (1926).

[5] *Ibid.*, p. 105; Pl. LXI, fig. 2; Pl. LXII, figs. 1-3.

[6] Foerste, *op. cit.*, p. 231; Pl. XXVII, fig. 1-A, B and C; Pl. XL, fig. 3; Pl. LVI, figs. 2, 5; Pl. LIX, fig. 6, (1930).

[7] Registered number in the fossil collections of the Geological Survey of India, Calcutta.

mostly in a poor state of preservation. They comprise the following identifiable fossils :—

Hyattidina sp.
Loxonema sp.
Phacops sp.

NOTES ON THE FOSSILS.

Hyattidina sp.

(Pl. 3, figs. 17, 18 ?)

There is one small internal cast of a gently convex, brachial valve measuring about 6·5 mm. in length, which has a remarkably conspicuous, thick, triangular hinge-plate divided into two triangular lobes by a narrow, median slit and provided with a pair of short, sharply pointed crura. A thick, median ridge starts from its base and rapidly becomes thin and faint in its course forwards nearly to the anterior margin; posteriorly, it separates a pair of small, narrow, deeply impressed, posterior adductors and a pair of larger, oval, anterior adductors, from the front of which run outwards and forwards a pair of long, narrow, straight, vascular sinuses diverging at about 45°.

This specimen much resembles a shell from the Drummuck group of Girvan [1] referred by the author to the genus *Whitfieldella*, but it may belong to *Dayia*; the hinge-plate is, however, more like that of *Hyattidina*, especially resembling that of *H. congesta* (Conr.). [2] An example of this genus has been described by the author from the Slade beds [3] of Haverfordwest as *H. pentagonalis* (Reed), a species which typically occurs in the Keisley limestone,[4] and was first referred to the genus *Dayia*.

It is probable that the internal cast of a pedicle-valve (fig. 18) of a smaller shell, also from the hill behind Taunggyi, belongs to the same genus. This specimen, which measures about 4 mm. in length, is moderately convex with a somewhat pointed beak, from which proceed a pair of long, narrow, deeply impressed, divergent diductors, reaching fully three fourths the length of the shell and

[1] Reed, *Trans. Roy. Soc. Edinb.*, Vol. LI, pt. IV, No. 26, p. 954; Pl. XXIV, fig. 52. (1917).
[2] Hall and Clarke, Palæont. New York, VIII, Brach. II, p. 61; Pl. XL, fig. 27.
[3] Reed, *Geol. Mag.*, Dec. V, Vol. II, p. 452; Pl. XXIII, fig. 20, (1905).
[4] Reed, *Quart. Journ. Geol. Soc.*, Vol. LIII, p. 75; Pl. VI, figs. 5, 5a, (1897).

diverging at about 35°. Between them, the shell is much thickened, especially in the fork. A pair of rather stout, short teeth are also present, and there is a narrow, submarginal, concentric thickening all round the valve. We may note that it bears a considerable resemblance to Cooper's *Cyclospira* ? *canadensis* [1] from the Upper Ordovician of Quebec, the generic reference of which is doubtful.

Loxonema sp.

The impression of six whorls of a long, slender, twisted gasteropod measuring about 17 mm. in length indicates a shell of about 10—12 whorls when complete, and suggests *Loxonema striatissima*, Salter, of the Keisley limestone [2]. The whorls are convex, smooth, about 1½ times as wide as long, and slowly increase in size from the apex; the suture line is oblique to the axis and sunken. The apical angle must have been about 10°. The lowest whorl preserved in our specimen measures about 5·5 mm. in diameter. There is no trace of a band as in *Hormotoma*.

Phacops sp.

The impression of part of the eye of a *Phacops*, showing some of the lenses, is the only evidence of the occurrence of this genus

B. SILURIAN.

Locality (?) Half a furlong west of bridge 378, Feho-Namnoi railway section.

NOTES ON THE FOSSILS.

Orthis (*Dalmanella*) *mansuyi*, Reed.

Three small pieces of a fine-grained, brownish sandstone tending to have a flaggy fracture contain the impressions of several brachial and pedicle-valves of a small, subcircular species of *Orthis*, averaging 6—7 mm. in length. It is not distinguishable from *O. mansuyi*, Reed,[3] described from the Panghsa-pye beds of the Northern Shan States, and seems to be allied to the common

[1] Cooper, *Amer. Journ. Sci.*, Vol. XX, p. 281; Pl. II, figs. 7, 8, (1930).
[2] Reed, *op. cit.*, p. 78; Pl. VI, fig. 6, (1897).
[3] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 1, p. 73; Pl. X, figs. 13-21, (1915).

European *O. elegantula*, Dalm. Internal casts are poor, but the external characters and ribbing are well displayed in many of the present specimens, and as previously remarked in the original description of the species, there is some variation in the ribbing.

Proetus sp.

The internal cast of a small, semi-circular pygidium, measuring 6 mm. in length and 11 mm. in width, has a stout, semi-cylindrical axis very slightly tapering to its bluntly rounded end, which touches or nearly touches the faint marginal groove that marks off the narrow, smooth, slightly raised border. The axis is annulated but owing to the destruction of much of its posterior surface, only 3—4 rings on its anterior half can be seen. The axial furrows are deep; the lateral lobes are weakly convex and show four pairs of pleuræ ending at the border. We may refer this pygidium to the genus *Proetus* rather than to *Portlockia* or *Acaste*, but it is too imperfectly known for us to feel sure as to its affinities.

Cyphaspis cf. *convexa*, Corda.

On one of the small pieces of rock containing specimens of *Orthis mansuyi*, there is a very small, imperfect free-cheek which suggests the trilobite from Tonkin compared by Mansuy [1] with *Cyphaspis convexa*, Corda. Our specimen has a shape indicating a somewhat subquadrate, rounded or semi-elliptical head-shield, for the outer edge of the free-cheek descends somewhat steeply from the rounded front to meet the posterior edge nearly at a right angle. There is a short, straight, tapering spine at the genal angle, projecting outwards and backwards so as to make an obtuse angle with the outer edge of the cheek. The narrow, lateral border is smooth and is sharply marked off by a marginal furrow from the convex, swollen, granulated ? surface of the cheek. The eye is situated at about half the length of the cheek, and the facial suture (so far as it is observable) agrees with that of *Cyphaspis*. It is noticeable that the Indo-Chinese specimen figured by Mansuy occurs in Silurian beds associated with the Burmese *Ph.* (*Dalm.*) *longicaudatus* var. *orientalis*, Reed, which possibly also occurs in these beds from Heho (see below).

[1] Mansuy, *Mém. Serv. Géol. Indo-Chine*, Vol. II, fasc. 5, p. 13; Pl. I, fig. 3, (1913).

Phacops (*Dalmanites*) sp.

There is a portion of a thoracic ring of a rather large trilobite on one of the pieces of rock containing *Orthis mansuyi*, and alongside it there is the outer portion of a free-cheek which may belong to the same species. The thoracic segment shows half of a gently rounded, axial ring and the inner part of the pleura which has a gently rounded surface traversed diagonally at a small angle to its anterior edge by a strong, straight, oblique, rounded, pleural furrow. Both the axis and pleura have their surface ornamented with small, rounded, sparsely distributed tubercles and a fine granulation.

The portion of a free cheek has a flattened or gently convex, smooth border marked off by a strong furrow which sweeps round sharply at the genal angle to meet the similar occipital furrow at about 45°. There is a strong genal spine, stout at the base, and curving back in direct continuation of the lateral edge of the cheek. The cheek itself seems to have its surface tuberculated like the thoracic segment. Probably both these fragments belong to some species of *Phacops* like *Ph.* (*Dalmanites*) *longicaudatus* var. *orientalis*, Reed,[1] from the Namhsim sandstones of Panghsa-pye and the Silurian of Tonkin.[2]

Locality (2) Loilem.

Palaeocyclus ? sp.

One small piece of rock contains the internal cast of the calyx of a small, simple, circular, subdiscoidal coral measuring 3·0—3·5 mm. in diameter and apparently only 1·5—2·0 mm. in height. On this transverse section, which apparently represents the calyx, eighteen simple, straight, strong septa of equal ? length can be seen, not quite reaching the centre, which is unoccupied by any columella or other structure, being therefore represented in the cast by a small circular plug. The generic reference of this small coral may possibly be *Palaeocyclus*, and if so, the age of the rock is likely to be Silurian. But it is not like the coral *Palaeocyclus ? haimei*, Reed,[3] described by the author from the Panghsa-pye beds.

[1] Reed, *Pal. Ind.*, N. S., Vol. II, Mem. No. 3, p. 138; Pl. VIII, figs. 5-11, (1906).
[2] Mansuy, *op. cit.*, p. 12; Pl. I, fig. 1, (1913).
[3] Reed, *Pal. Ind.*, N. S., Vol. VI, Mem. No. 1, p. 71; Pl. X, figs. 7-11, (1915).

Locality (3) Band overlying Pindaya beds to the west of Wabya.

(Collection by V. P. Sondhi

F. 8. *Monograptus cyphus* Lapw
incommodus, Tqt.
,, *sandersoni*, Lapw.
Orthograptus vesiculosus, Nich.
Climacograptus medius, Tqt.
Glyptograptus tamariscus, Nich. var. *incertus* (large form or new var.).

F. 12. *Monograptus cyphus*, Lapw.
,, *incommodus*, Tqt.
Orthograptus vesiculosus, Nich.
Climacograptus medius Tqt.
, ? *rectangularis*, His.
,, sp.
Glyptograptus tamariscus, Nich. var. *incertus* (? large var.).
Mesograptus magnus ?? (too poorly preserved for certainty).

According to Miss Elles, who has kindly identified these specimens for me, this assemblage of graptolites indicates the *Monograptus cyphus* zone, which has been found previously in the Panghsa-pye graptolite band in the Northern Shan States.[1] Two types of shale occur in this collection from above the Pindaya beds, one being a black shale, and the other a pink shale, but the difference in colour is probably due to weathering, as in other characters and contents they are similar.

Locality (4) Panghkawkwo, near Loilem.

Glyptograptus serratus, Elles & Wood
Monograptus sedgwicki, McCoy.
,, *regularis*, Tornq.
,, *distans*, Lapw.
,, *lobiferus*, McCoy.

[1] Reed *Pal. Ind.*, N. S., Vol VI, Mem. No. 1, pp. 69, 87, 88, 94, 97, (1915)

Climacograptus scalaris, His.
Retiolites sp.

The rock in which these graptolites occur is a whitish shale and according to Miss Elles they indicate the zone of *Monograptus sedgwicki* and, therefore, a higher horizon than that of the band overlying the Pindaya beds. This zone has not so far been found in the Northern Shan States.

EXPLANATION OF PLATE 3.

Fig. 1. *Yeosinella consignata*, gen. et sp. nov. Internal cast of brachial valve. ×3. Yeosin. (A. 484)

„ 1*a*. *Yeosinella consignata*, gen. et sp. nov. Same specimen, showing cardinal process, etc. ×9. Yeosin.

„ 2. *Yeosinella consignata*, gen. et sp. nov. Impression of exterior of same brachial valve. ×3. Yeosin. (A. 484)

„ 3. *Leptelloidea yeosinensis*, sp. nov. Internal cast of brachial valve. ×4. Yeosin.

„ 4. *Leptelloidea yeosinensis*, sp. nov. Internal cast of another brachial valve. ×5. Yeosin.

„ 5. *Leptelloidea yeosinensis*, sp. nov. Impression of exterior of pedicle-valve. ×4. Yeosin.

„ 6. *Leptelloidea yeosinensis*, sp. nov. Impression of exterior of brachial valve. ×4. Yeosin.

„ 7. *Orthis (Dalmanella) emancipata* sp. nov. Internal cast of brachial valve. ×4. Bawzaing.

„ 8. *Orthis (Dalmanella) emancipata*, sp. nov. Internal cast of brachial valve. ×4. Bawzaing.

„ 9. *Orthis (Dalmanella) emancipata*, sp. nov. Internal cast of pedicle-valve. ×3. Bawzaing.

„ 10. *Orthis (Dalmanella) emancipata*, sp. nov. Internal cast of pedicle-valve. ×3. Bawzaing.

„ 11. *Orthis (Dalmanella) emancipata*, sp. nov. Internal cast of brachial valve. ×4. Bawzaing.

„ 12. *Orthis (Dalmanella) emancipata*, sp. nov. Impression of exterior of brachial valve. ×4. Bawzaing.

„ 13. *Orthis (Dalmanella) emancipata*, sp. nov. Impression of exterior of pedicle-valve. ×3. Bawzaing.

„ 14. *Orthis (Dalmanella) emancipata*, sp. nov. Impression of exterior of surface showing minute nodules on ribs. ×5. Bawzaing.

„ 15. *Ptychoglyptus shanensis*, sp. nov. Pedicle-valve. 4. Yeosin.

„ 16. *Petroria* cf. *rugosa*, Wilson. Pedicle-valve. ×3. Yeosin. (A. 490.)

„ 17. *Hyattidina* sp. Internal cast of brachial valve. 3½. Hill behind Taunggyi. (K. 15·124)

„ 18. *Hyattidina* sp.? Internal cast of pedicle-valve. ×3. Hill behind Taunggyi. (K. 15·124)

NOTE ON THE GEOLOGY OF NANGA PARBAT (MT. DIAMIR), AND ADJOINING PORTIONS OF CHILAS, GILGIT DISTRICT, KASHMIR.

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CONTENTS.

I. INTRODUCTION.

Nanga Parbat[1] (35° 14′: 74° 35′), elevation 26,620 feet, the culminating peak of the north-west Himalaya, rises in solitary eminence among the mountains of northern Kashmir, none of which, within a radius of 60 miles, attains an altitude of more than 17,000 feet. From the point of view of

Nanga Parbat peak.

[1] This name is of Hindi derivation, meaning *the bare mountain*, but the inhabitants of the district (Dardistan) do not know it and call the mountain by its Dard name, 'Diamir,' or 'Deomur,' meaning *the abode of fairies*. A picturesque legend is associated with this name. The Dard legend is that there are a number of favoured human beings at present living in the snows of Nanga Parbat, these being some hardy adventurers who had gone beyond ordinary limits, were seen and liked by the fairies and were prevailed upon to stay with them. Ultimately they were wedded to the junior fairies of the Abode. I was told that besides one or two Dards and a few people from the Panjab, there is at least one European, beloved of the fairies, who is leading a happy semi-celestial life in the dazzling snows of Nanga Parbat. Mountaineers whom the fairies do not like are turned back and, of course perish in the snows.

mountain morphology it is a peak of arresting grandeur, when compared with the shapeless mass of rock and glacier such as K[2] (28,250 feet), another giant of the north-west, or with the 'lumpy tetrahedron' of Mt. Everest itself (29,002 feet). Its southern flank exposes a rock face whose buttressed cliffs, 12,000 feet high, pierce the sky almost in one leap; while the naked escarpments which face to the east are no less abrupt and majestic. Although Nanga Parbat must be regarded as a portion of the Great Himalaya range, yet it is not on the watershed between the Indus and the Jhelum, but stands out as a mighty spur to the north. To the south and south-west, it presents stupendous, bare precipices of naked rock, but to the north the aspect is tame, though this flank ascends in one single stride 22,500 feet from the bed of the Indus within barely 14 miles.

This slope is concealed under nearly 100 square miles of uninterrupted snow-fields, drained by a number of small glaciers, the three largest of which, on the southern and eastern faces, descend nearly 8,000 feet below the snow-line. Of these the Tarshing and the Satshe descend close to the camping grounds of Tarshing hamlet (35° 14′: 74° 44′) and Ramah (35° 21′: 74° 47′).

II. MAPS AND LITERATURE.

No good, recent, topographic maps of this region exist, though the area is at present under survey and before long the beautifully executed modern maps, such as are now issued by the Survey of India, will become available. The only maps obtainable at present are (1) the ¼-inch sheet (43 I); and (2) the ½-inch sheet ($43 \frac{I}{SW \& SE}$) of the old Northern and Trans-Frontier Survey. The former is based on old reconnaissance surveys with inaccurate and sketchy topography, even in the broader features, while the contouring is conjectural; in the latter the broader details are well delineated, but the minor relief and relative altitudes are not represented.

Topographic maps.

A very good account of the geography, physical aspects, ethnography, etc. of the ground (Dardistan) treated in this paper is given in F. Drew's 'Jummoo and Kashmir Territories,' London, (1875).

So far as the geology of the area is concerned, the greater part of Chilas is new ground to the Geological Survey, nothing having been published about it, although Lydekker has depicted the summit portion of Nanga

Previous literature.

Parbat as 'Archaean and Metamorphic Panjal' in his map (1 inch= 16 miles) published in 1883 in the Memoirs of the Geological Survey of India, Volume XXII. He, however, gives no account of the rocks nor of any other geological features of the mountain nor of the adjoining areas of Chilas and Gilgit. In an earlier paper in the Records,[1] he describes the gneiss of Astor and of the districts east of it and classifies it into 'primary gneiss' and 'Silurian gneiss'; in the latter gneiss he includes all the large epidiorite intrusions. No geologist has been in this area since Lydekker's day.

In his important expedition to the Karakoram glaciers in 1892,[2] Mr. Martin Conway (now Lord Conway) made a collection of the rock-types on the route of the traverse. These rock-collections, which included several types from the Gilgit area, were studied by Prof. T. G. Bonney and a petrological account was published in the Proceedings of the Royal Society in 1891.[3]

In 1900, Gen. C. A. McMahon described a number of rock specimens, collected from various parts of Gilgit, Hunza and southern Pamirs, Yasin, etc., by his son Capt. McMahon and Capt J. R. Roberts.[4] Gen. McMahon had no opportunity of visiting the region covered by his paper and his descriptions pertain to the different rock-types occurring in the area, without reference to their geological and field relations. Nevertheless, he has made some shrewd observations on the character and distribution of the main varieties of granitoid gneisses of this area, which are a considerable improvement on Lydekker's ideas.

In 1914, Sir Henry Hayden, during his traverse to the Pamirs, passed through Gilgit, *via* Chitral, just touching the northern border of the area treated in the present paper. He has given a description of the rock-groups he encountered on his way from Gupis to Gilgit.[5]

[1] *Rec. Geol. Surv. Ind.*, XIV, p. 4, (1881).

[2] W. Martin Conway: 'Climbing and Exploration in the Karakoram-Himalayas', London; and Vol. II, Scientific Reports, p. 41, (1894).

[3] *Proc. Roy. Soc.*, Vol. LV, p. 468, (1894).

[4] *Quart. Journ. Geol. Soc.*, Vol. LVI, pp. 337-367, (1900).

[5] *Rec. Geol. Surv. Ind.*, XLV, p. 297, (1915). Hayden's description of the rocks occurring to the north-west of Gilgit is as follows:—'The metamorphic series consisting of crystalline limestone, calc-schists, calc-gneisses, quartzites and amphibolites continue all the way to Gilgit penetrated by, and sometimes giving place to, great masses of granite'. This description would apply equally well to the Salkhala rocks (p. 218 *et seq*) immediately to the south-east of Gilgit.

III. PHYSICAL ASPECTS.

Depth of vertical relief.

A profile section through Nanga Parbat in any direction reveals a depth of dissection into the surface of the earth's crust that can but rarely be equalled in any other mountain region. The depth of vertical relief of the ground reaches the extraordinary total of 4½ miles within a relatively short horizontal distance. To the north, the ground level falls from 26,600 feet to below 3,500 feet at the Indus bed near Drang (35° 24′ : 74° 26′), a radial distance of 14½ miles. To the west, it falls 20,600 feet in 17 miles; to the south, 20,000 feet in 31 miles and to the east, within 14 miles there is a drop of 19,600 feet to the Astor gorge. Nor do these figures express the maximum relief; for, within the main declivities on all sides, there are numerous abrupt scarps, deep gorges and basins of from 5,000 to 10,000 feet relief, which again and again break the main fall.

Nanga Parbat massif.

The Nanga Parbat mountain mass, the central and most commanding feature of the whole district, is, above 15,000 feet level, almost inaccessible to single field geologists, unequipped with elaborate mountaineering outfit, parties of carriers, etc. The wall-like precipices of the south, rising sheer 12,000 to 13,000 feet from the Rupal valley beneath, carry in their ledges and recesses numerous small hanging glaciers. The ever-present danger from avalanches from this face, as well as the unrelieved snow-cap on the north face, alike forbid approach. The southern side of the mountain, from the base to the Mazeno pass (17,925 feet ; 35° 12′ : 74° 29′), leading to the Bunar valley in Chilas, lies concealed under a mantle of talus and moraine deposits. Enormous stretches of moraines, consisting of angular blocks of all sizes up to 100 feet diameter, surround the mountain on all sides, and these, together with the fresh, frost-bitten debris, continually shed from the higher crags and hurled down by avalanches, provide at places the only material for the investigation of the geological composition of the mountain above the snow-line. The uniformity that prevails in these extensive moraine and scree deposits on every side of the mountain and the constant, unvarying association of the few petrographic types present at every point where the moraines have been examined by me, constitute good positive evidence regarding the essential rock-constituents of the higher parts of the mountain, though obviously such evidence is not capable of application in a negative sense. Good natural sections, revealing the

geological structure as well as composition of Nanga Parbat, occur below the snow-line and are accessible from the village of Tarshing (Tashina on the map). Discontinuous patches of bare rock occur along the whole length of the Rupal valley, between Tarshing and the Tosha group of peaks (35° 10′ : 74° 26′). To the north, the naked cliffs, overhanging various parts of the streams tributary to the Indus, along the road to Chilas, afford many good exposures and sections. To the north-west and north-east, this region falls precipitously to the deep defile of the Indus, rising again as steeply but to a much less total altitude, to the mountains of Gor and Harpai. These mountains lie within the trans-Himalayan desert zone and are utterly sterile and forbidding; but their geological structure is laid bare in a number of well-exposed scarps and cliffs. Similar is the case with the ground to the south of the Nanga Parbat *massif*, where, though the mountains are quite uninhabited and possess an exceedingly high relief, geological field work is faced with no great difficulties, owing to the clarity and profusion of good rock exposures.

The surrounding parts.

Physiographically, the Indus basin of Gilgit belongs to the Central Asian desert belt. It is a sterile and inhospitable expanse of rock-desert, devoid of soil, but covered under a drab regolith of its own scree materials.

IV. GEOLOGICAL COMPOSITION.

From the point of view of geological composition, the following lithological elements have been distinguished in the Nanga Parbat area, comprised between Chilas on the west and Astor and Bunji (Bawanji) on the east:—(1) Biotite-gneiss composing the Nanga Parbat *massif*, with its granitic intrusions; (2) the Salkhala series (pre-Cambrian) constituting the area to the south of about latitude 35° 13′; (3) a crystalline complex showing an intimate association, in variable proportion, of the gneiss and Salkhala series, surrounding the central gneiss *massif*; (4) masses of black basic igneous rocks intrusive into the former units, occupying extensive ground to the north and east of the Indus. Besides these elements, in the northern corner of the map, just to the south and west of the Gilgit group of hamlets, there occurs a patch of metamorphosed Dogra slate.

Main lithological units.

(*a*) *Gneiss of Nanga Parbat*: Type areas—Nanga Parbat mountain; Hattu Pir; Bunji; and eastern slopes of Bunar valley. The geology

of Nanga Parbat proper is found to be, considered broadly, rather simple. The mountain-mass with its group of satellite peaks, is composed almost entirely of fine-grained, thinly-foliated, much-contorted, streaky, or slaty biotite-gneiss, with subordinate inter-stratifications of coarsely recrystallised marble, calciphyre, calc-schists, banded granulites, and garnetiferous mica-, graphite-, and actinolite-schists. The whole assemblage, in spite of a considerable amount of crumpling, is finely and uniformly laminated, having a persistent regional dip to the north-west. The general strike of the foliation is, except for local variations, consistently N.E.–S.W., from Babusar (35° 13′ : 74° 4′) in Chilas to Bunji (35° 40′ : 74° 37′) on the Indus, a distance of 60 miles. This is also the evident grain of the mountains from Hazara, all through eastern Chilas, to Rondu in Baltistan. The biotite-gneiss and schists are extensively traversed by acid and basic igneous intrusions; the latter are less voluminous but to them belong the ubiquitous black dolerite masses, now represented by widely distributed sheets and lenses of massive epidiorite, amphibolite and hornblende-schist. Due to the prevailing tectonic stresses, these basic injected masses have also assumed stratiform shapes, being drawn out into elongated sills, lenses and phacolites, closely interfoliated with the gneisses and schists and obeying the same regional strike. The acid intrusions are of two types and are of considerable dimensions, (1) the gneissic granite belonging to the Himalayan 'Central gneiss' and (2) a finer grained hornblende-granite belonging to a later intrusive phase.

Gneiss of Nanga Parbat and 'Central gneiss.'

It should be mentioned here that the biotite-gneiss, which constitutes the higher portion of Nanga Parbat, is in fact a foliated granite (biotite-granite) which has intruded into the gneiss of the Nanga Parbat *massif*. This granite belongs to the type of gneissic granite which occurs so largely in the central and north-western Himalaya and which, on account of the *axial* position, was designated by Stoliczka [1] 'Central gneiss.' Alike in composition and petrographic facies, this gneissic granite is different from the gneiss of Nanga Parbat (probably a paragneiss), into which it is injected, though at some places the two rocks have a strong external resemblance, both having the aspect of a thinly foliated biotite-gneiss. The 'Central gneiss' is very prevalent in the Kishen-

[1] *Mem. Geol. Surv. Ind.*, V, p. 15, (1866).

ganga valley to the south of the Barai pass (35° 4′: 74° 17′) and in the upper Kaghan valley.

A paragneiss.

From an examination of a large number of specimens of the biotite-gneiss of Nanga Parbat, collected from numerous localities distributed over the lower north-western and south-eastern slopes of the mountain, the present writer entertains no serious doubt that the bulk of the slaty, contorted gneiss is a para-gneiss, a transformation product of a highly characteristic group of pre-Cambrian sediments, with a notable calcareous and carbonaceous content, which he has distinguished over wide areas in Hazara and north-western Kashmir under the name of the Salkhala series.[1] With this gneiss are associated mixed or composite gneisses produced by the *lit-par-lit* injection and permeation of true granites of the 'Central gneiss' type, thus forming a complex in which the constituent elements are impossible of separation. The last-named element predominates in the higher parts of the *massif*, for, in the moraine blocks that have come from elevations over 20,000 feet, the prevalent rock is a more monotonous, foliated and crumpled biotite-granite, with scarcely any calcareous bands. This is clearly seen from the detritus carried on some of the transverse glaciers, tributary to the main Rupal stream, which reach back to the cliffs immediately below the highest peaks. These moraines, unmingled with any debris from the sides, are the scree from the summit of Nanga Parbat, whose composition it is thus possible to ascertain with a fair amount of certainty. The examination of this gneiss proves it to be of a pale-coloured, thinly foliated, felspathic granite, although but little different in aspect from the gneiss of lower levels. This gneiss is without any marked stratification. The summit region of Nanga Parbat is fully exposed to view to one standing on the narrow ridge between the Chhichi ravine and the Rupal basin and can be seen with field-glasses on a clear day when the top of the mountain is free from the usual enveloping mist.

(*b*) *Salkhala series*: Type area—south of Nanga Parbat. Also south of Babusar; Rattu; and the mountain north of Thalichi.

Pre-Cambrian sediments.

In its typical facies this series of rocks consists of highly metamorphosed slates and

[1] *Rec. Geol. Surv. Ind*, LXV, p. 196, (1931).

phyllites, with prominent carbonaceous and graphitic bands, interstratified with carbonaceous limestones and marble, often dolomitic, and associated with quartzites and quartz-, mica-, chlorite- and talc-schists. Its lithological resemblance to the Jutogh series of the Simla hills is very close, the resemblance also extending to the fact that these rocks constitute the oldest sedimentary formation of the area, the basement of all subsequent rock-systems. Its age is pre-Cambrian, being definitely pre-Dogra slate (Attock slate), occurring as a rule in much-disturbed inliers in the latter and showing a distinctly higher grade of regional metamorphism.

Previous field work in the Kishenganga valley to the south and in the Kaghan basin to the south-west of Nanga Parbat, had established the occurrence of the Salkhala series, of a moderate grade of metamorphism, as the country-rock of the entire district from south Chilas in the north-west to Gurez (Gurais) in the east.

Their regional metamorphism.

While the characteristic elements of Salkhala lithology are easily recognised below a level of 10,000 feet all along the foot of Nanga Parbat, at higher altitudes the calcareous and graphitic bands become distinctly scarcer, the schists turn more micaceous, and the impure marble-beds become converted into richly garnetiferous calc-gneiss, as is observed on the slopes above Tarshing and Leychar (35° 31′ : 74° 38′), and in the Bunar valley to the west. The purer and coarser grained marbles alone preserve their identity and remain recognisable, though these are also crowded with newly crystallised calc-silicates, *e.g.*, tremolitic amphibole, scapolite, idocrase, forsterite, paragonite, epidote, etc. A pearly brown mica (paragonite) is a highly conspicuous ingredient of the altered calcareous sediments. The slaty and phyllitic constituents are replaced by pale-coloured, rather highly felspathic, banded, biotite-gneiss of grey, brown, red, or purple tints, locally crowded with garnets of the size of peas, or even at times of cherries. Hornblende-gneiss is rare in this part, though hornblende occurs locally with biotite. Some of the interbedded biotite-schists, besides containing garnets, occasionally carry small crystals of sillimanite and kyanite.

Proceeding, on the other hand, in an opposite direction, *i.e.*, south-east from Tarshing, across the main strike of the rocks, a distinct decrease in the degree of metamorphism becomes perceptible near Rattu (35° 8′ : 74° 49′), and rocks of typical Salkhala facies emerge from the monotonous gneissic complex. The number, as

well as the volume of the acid and basic injections, steadily decreases south-eastwards, and at the crossing of the Great Himalaya range, by the Kamri Bal pass (34° 48′ : 74° 56′) on the Gilgit-Srinagar road, and the various other passes leading to Chilas from the Kishenganga basin, the normal facies of the Salkhala series is restored, the facies which prevails over wide areas in the basins of the upper Kishenganga and Kunhar valleys.

(*c*) *Zone of mixed Salkhala and gneissic rocks*: Type area—an ellipse surrounding Nanga Parbat, prolonged northwards to Gilgit. At the head of the Kaghan valley, the Salkhalas (here consisting of a series of alternating strata of thinly-foliated gneiss, with marble, calc-granulites, garnetiferous graphite-schists, etc.) show a progressive increase in metamorphism, ultimately grading into the central gneissic complex of the Nanga Parbat *massif*, the change being so transitional as to make the drawing of a geological boundary line difficult. In the accompanying map (Plate 7) an attempt is made to illustrate this change of rock-type and the disposition of the metamorphosed zones relative to each other, but the field work in this part has not been of such a character as to warrant the drawing of exact boundary-lines between them. The main Salkhala outcrop of the south is divisible into two parts, marked by different degrees of association with gneiss. In the west, or Babusar—Gittidas area, the gneiss is subordinate to the Salkhalas, while in the eastern part, *i.e.*, in the Astor valley, the association of the gneiss and schists with the less-altered sediments has become closer and the accompanying metamorphism of a higher grade, though enough of the essential sedimentary nature of the rocks, is yet evident to warrant the designation of this outcrop still by the name of Salkhala. In the north-easterly prolongation of these two arms of the main outcrop, along the regional strike, towards the Indus, a marked change becomes perceptible near Upper Babusar in the former arm, and near Garhkot (35° 15′ : 74° 47′) in the latter, the gneiss becoming the predominant rock element in the complex (of the character and composition described above). As if like small islands or archipelagoes in a sea of gneiss, are to be observed, at nearly all parts of the course of this band, wisps or shreds of Salkhala sediments that have withstood or escaped the prevailing gneissification. This gneissified Salkhala rock is seen in a broad elliptical rim round the central crystalline mass of Nanga

Interbedded gneiss and Salkhala rocks.

Parbat.[1] The rim of the ellipse continues in a N.N.E. direction beyond Astor and Bunji towards Gilgit and Rondu. As above noted, the higher and central part of the Nanga Parbat *massif* is more exclusively constituted of gneiss, and though it is probable that portions of it are only more intensely altered sediments of Salkhala age, the greater portion of it is more probably an ortho-gneiss or foliated granite, the Himalayan 'Central gneiss', intruded into the former at a later age. It is, however, especially along its periphery, so intimately associated with the former that it would be more correct to designate much of the resulting compound as *injection gneiss* or *permeation gneiss*.[2]

The fact that the metamorphism of the Salkhala sediments is of a differential or patchy nature is well borne out by the observation of patches of comparatively little altered marble, graphite-slate and phyllite which occur outside the ellipse, to the north of the Indus. The largest of these is the mass of bedded and highly contorted marble and slate which occupies a commanding line of gaunt, tortuous cliffs over-hanging the Indus bed on the right bank and extending from north of Thalichi (35° 36′ : 74° 37′) to near Bargin (35° 40′ : 74° 35′).

(*d*) *Acid and basic igneous intrusions*: The whole area under description is characterised by widespread injections of acid plutonic and basic plutonic and hypabyssal rocks.

The acid intrusions.

The acid plutonic intrusions are:—(1) the Himalayan 'Central gneiss' of the usual facies recognised in the porphyritic, biotitic gneissic granite masses so common in the Purana and crystalline belt of the Himalaya from Garhwal to Chitral. This gneissic granite, often tourmaline-bearing, with pegmatitic apophyses, has been frequently described;[3] (2) a fine-grained hornblende-granite of white, or pale grey colour, rather rich in sphene, occurs in the Burzil, Chillum (35° 5′ : 75° 6′) and Gilgit valley tracts in a series of discontinuous masses, penetrating the drab or dark coloured

[1] For the method of representing these peculiar 'mixed gneiss and sediments' zones on the accompanying map, I am indebted to Dr. L. L. Fermor. The method that he suggested has, besides depicting the actual facts observed in the field in a better manner, revealed the tectonic strike very clearly on the map.

[2] These terms are used here in the sense in which they are defined by Dr. H. H. Read in his 'Geology of Central Sutherland,' *Mem. Geol. Surv. Scotland*, pp. 118-120, (1931).

[3] *Mem. Geol. Surv. Ind.*, XXII, p. 266, (1883); *op. cit.*, XXVI, p. 61, (1896); *op. cit.*, LI, p. 223, (1928); and LIII, p. 52, (1928). *Rec. Geol. Surv. Ind.*, XXI, p. 150, (1888).

prevalent basement rocks of the country, as well as the dolerite and epidiorite masses described below.

North of Bunji, along both banks of the Indus, injections of granite-veins in the epidiorites give a misleading appearance of stratification to the rocks. Though generally intersecting and forming an intricate network, the larger veins have a dominant E.N.E.—W.S.W. strike direction with a prevalent north-westerly dip. These veins are sometimes of a pegmatitic nature with crystals of muscovite and biotite four to five inches across.

Doleritic intrusions.

The dolerite intrusions of Astor, and of the Indus valley to the north and east of Nanga Parbat, occupy an enormous surface extent and are of mountainous dimensions, being several miles in length and width, occurring as bathyliths and stocks of a black-green, structureless rock of forbidding aspect, thrust into the grey or white biotite-gneiss. Smaller intrusions in the form of dykes and stocks are ubiquitous. The intrusive contacts at some places are sharp and well-defined, with anastomosing veins of the one rock ramifying through the other, or with alternating sheets of gneiss and dolerite; at other localities, considerable amounts of mixture or incorporation of the two rocks has taken place, resulting in a compound or hybrid-rock, occupying a fairly wide belt of intermediate composition at the plane of contact. The latter phenomenon is well observed along the road descending the Babusar pass to the village of Babusar for a distance of about two miles. On the other hand, in sections exposed between Astor (35° 21′ : 74° 52′) and Tarshing, as well as near Chillum, Dashkin (35° 27′ : 74° 47′), and Doyan (35° 33′ : 74° 42′), all localities situated either along or not much removed from the main Kashmir-Gilgit road, the two rocks show complete immiscibility and preserve their identity intact in even the smaller veins and ramifications. At these sites, intricate black-and-white mosaic patterns are not infrequently seen on exposed surfaces of rocks.

Epidiorites.

The original dolerites of the Nanga Parbat region are, in the majority of cases, if not invariably, uralitised to a black, lustrous hornblende-rock with stout prisms of hornblende, sometimes two to four inches long, largely replacing the original augite. At times, the rock has a dioritic aspect with the normal content of white or grey plagioclase felspar, but often it has a higher basicity approaching, in the end product, an amphibolite in composition. A few occurrences of uralitised pyroxenite

have been noted, in which about one-third of the original augite is yet unaltered. Locally, the hornblendite is found to be serpentinised in large masses; this is the case with the ultra-basic segregations (originally picrite and pyroxenite) of the doleritic magma. Such segregations occur sporadically all round Nanga Parbat, those of Godai (35° 11′ : 74° 56′), Khakan (35° 7′: 75° 5′), and Pashwari (34° 46′ : 75° 2′) on the road to the Burzil pass (34° 53′ : 75° 6′), and of Chechri (34° 55′ : 74° 54′) and Babusar (35° 10° : 74° 3′) being the most conspicuous. At the three last-named localities, a handsome dark-green serpentine of oily lustre crops out close to the road section, its debris strewing the country-side.

As differentiation-products in the dolerite intrusions, small stocks, plugs and sills of uralitised gabbro, together with its modifications norite and pyroxenite, are met with. There are no peridotites nor dunites, olivine having, so far, not been observed as a prominent mafic constituent in the Nanga Parbat area. The serpentines are in all cases the result of the alteration of pyroxenites and not of dunites.

Field work, as well as study under the microscope, has shown that the intrusive dolerites bear close petrographic resemblance and magmatic relationship to the Panjal trap lava-flows. Near Chechri, 23 miles south-east of the peak of Nanga Parbat, a definite genetic connection can be traced in a southward direction from the hypabyssal dolerite dykes and stocks to the surface volcanic lava-flows, ash-beds, and agglomerates of the Panjal volcanic series on the one hand and into the extensive basic bathyliths of the Rattu area (which continue further northward in a line of black mountains as far as Rondu) on the other.[1]

Genetic connection with Panjal traps.

Mention may be made here that the numerous dolerite dykes injected into the Silurian and older Palæozoic rocks of Lolab and Hundwara district, to the south of the present area, have also been traced into genetic connection with the amygdaloidal lava-flows of the Panjal trap series.

So far as it is possible to judge from field evidence, the basic rocks of this area all belong to one intrusive phase, namely, the one connected with the great Upper Carboniferous and Permian volcanic period in Kashmir, when

Age of the intrusions.

[1] A similar genetic connection has been observed between the basic plutonic and hypabyssal intrusives and surface volcanic flows belonging to the same stratigraphic series in the Pir Panjal range, *vide*: *Mem. Geol. Surv. Ind.*, LI, pp. 193 and 220, (1928).

some thousands of square miles of Kashmir was flooded with basaltic lava eruptions. The ultra-basic rocks are only segregation-products and do not represent a separate eruptive phase.

Post Permian age of the hornblende-granite.

The acid intrusions, on the other hand, belong to two distinct periods and are more or less definitely dated, the one being post-Dogra slate[1], the other post-Panjal -trap. To the former belong the 'Central gneiss' bodies protruding through the Salkhalas and Dogra slate of Kaghan and the crystalline tracts of the Kishenganga. In the present area, they are not so conspicuous by reason of the host itself being a gneiss (instead of being a pelitic foundation as in the previous case) though probably the volume of the acid intrusives here is no less than in the former areas. The white tourmaline-granite of Nanga Parbat and the pegmatite veins of the surrounding parts are peripheral portions of this system of massive, bathylithic injections.

The following acid intrusions are post-Panjal trap in age. The hornblende-granite[2] mentioned on p. 221, is clearly later than the dolerite and epidiorite masses through which it pierces. The most important observation in this connection is the prominent mass of this granite which has cut through the bedding-planes of ash-beds and lava-sheets of the Panjal trap series one mile north-east of the Kalapani rest house (34° 52′ : 74° 54′) on the road to Kamri Bal pass (34° 48′ : 74° 56′). Smaller bodies of the same granite occur further south-eastwards, the one to the north of Minimarg (34° 49′ : 75° 5′) being the most conspicuous and typical of the rest. To the south of the Burzil (Dorikun) pass, scoriaceous and amygdaloidal doleritic rock is associated with hornblende granite. The ground, however, is here too much covered with snow and clear intrusive relations are not perceptible.

The order of intrusion of the plutonic igneous rocks in the present area is thus inferable on fairly trustworthy evidence. It may be stated as follows :-

(3) Hornblende-granite.--Post-Permian age;

(2) Dolerite, gabbro and pyroxenite.—Post-Carboniferous age.

(1) Himalayan 'Central gneiss'. Post-Dogra slate; probably much newer in age.

[1] The evidence from intrusive contacts obtained from contiguous areas, however, indicates a considerably younger age for the 'Central gneiss'.

[2] In its petrographic characters, as has been observed by Dr. A. M. Heron, this granite is very like the post-Jurassic, or probably late, or post-Eocene granite of the Everest region.

(e) *Metamorphosed Dogra slate* : No outcrop of the Dogra slate series has been noted in the Chilas area. The extensive development of this formation[1] in the north-west border ranges of Kaghan, in all probability continues in a N.N.E. direction through Darel and Chiraband tribal territory. The only occurrence of this series in the territory covered by the map accompanying this paper is a few square miles of metamorphosed slate-built mountains to the south and west of Gilgit. The monotonous composition of these well defined, linear ranges (consisting of thinly cleaved argillaceous slates, phyllites and fine biotite-schists), lacking any calcareous or carbonaceous contents, and without the usual suite of secondary minerals, is a ready means of distinction from the more susceptible and heterogeneous Salkhalas. The phyllites and slaty schists are interleaved by granite veins and sills. These hills near Gilgit are all tectonic ranges, as often before observed during work in neighbouring regions (*op. cit.*, p. 202). The Dogra slate outcrop of Gilgit appears to be of a restricted nature for, from the brief petrographical account which Hayden has recorded of the rock groups traversed by him on his way from Gupis to Hunza *via* Gilgit, it appears that the whole area to the north of Gilgit is again composed of undoubted Salkhalas, consisting of schists intercalated with marble, calc granulites, calc-gneiss, etc.[2]

Slate-built Gilgit hills.

(f) *Sub-recent deposits* : The sub-recent alluvial, glacial and sub-aerial deposits of this area deserve notice both on account of their magnitude and the slight auriferous content for which they have been noted since very early times. The Recent and Pleistocene sub-aerial alluvium and screes, which occupy a large superficial extent of the country, are such as characterise a desert region, being largely of the nature of a mantle of scree material, wide-spreading, gently sloping talus-fans, and wind-blown sand, and marked by the absence of fluviatile and lacustrine deposits, except in the immediate vicinity of the Indus and of its larger tributaries. There is no monsoon in this trans-Himalayan province and the rainfall is exceedingly fitful and scanty, the precipitation being restricted to snow-fall in

Desert type of surface deposits.

[1] *Rec. Geol. Surv. Ind.*, LXV, p. 201, (1931).
[2] *Rec. Geol. Surv. Ind.*, XLV, p. 297, (1915); also General McMahon has described specimens of rocks, evidently belonging to the Salkhalas, together with diorite, amphibolite, granite, etc., obtained from the Gupis-Gilgit-Hunza section; *Quart. Journ. Geol. Soc.*, Vol. LVI, p. 337, (1900).

the higher altitudes. The lower mountains are quite barren and repellent, mantled by a thick, drab cover of undecomposed regolith supporting no vegetation, except in a few cases. Long stretches of the Indus valley are occupied by wide banks of talus and wind-blown sand, supported on shingle and gravel terraces, which reach heights up to 1,500 feet above the beds of the streams.[1] There is no soil-cap, nor humus, except in the oases, of which Bunji and Gilgit are the largest in extent, the former being about three square miles, the latter about eight.

Recent lake deposits.

A notable feature of the Indus valley is the volume of lacustrine deposits of Recent age, *e.g.*, near Jullipur (35° 27′ : 74° 28′), Gor (35° 32′ : 74° 31′) and Bunji. They are the relics of the numerous temporary but extensive lakes formed by the damming effects of mountainous landslips as well as glacial barriers, which have occurred rather frequently during late historic times.[2]

Glacial moraines are of widespread prevalence in the higher valleys; the basins of the Rupal, the Tarshing, the upper Gonalo, the Rakhiot and the Buldar being choked with ice-transported blocks mingled with finer moraines. The path to the Mazeno pass is strewn with gneiss masses and blocks almost up to the summit. Erratics of 100 feet diameter and over are met with around Nanga Parbat at distances of 12 to 15 miles from the peak. At lower levels, the glacial alluvium merges into the scree and talus debris.

Alluvial and placer gold.

Gold washing in the alluvial terraces, beaches, and sand-banks has been practised for a long time in the Indus valley in Chilas, Gilgit, and the Skardu district further upstream, it being the chief industry, and a fairly remunerative one, of the thinly scattered population, especially during the winter months. The Hunza and Bagrot tributaries of the Gilgit river and a section of the Indus above Chilas are reputed to be richer than other parts. The gold occurs in the native form (20 carats, usually) as dust, flattened pellets and very occasionally as small nuggets in the gravel beaches and banks along the streams.

[1] At Chichuboi (35° 56′ : 74° 38′) are seen remnants of three terraces or benches at widely separate levels. Similar occurrences are noted between Gurikot and Astor, where as many as five terraces can be distinguished.

[2] For an account of some of the latest of these Indus floods, the cause of much destruction in Hazara and Attock, see F. Drew: Jummoo and Kashmir Territories, p. 414, London, (1875).

No lode-gold, or any deposits of the metal *in situ*, have so far been located, either in the present area or in the Indus basin of Skardu, Dras and Kargil to the east, where the panning industry is carried out on even a larger scale. In the pan, the gold is always associated with heavy, black magnetite sand.

V. TECTONIC RELATIONS OF THE NANGA PARBAT AREA.

North-easterly regional strike.

The region surrounding Nanga Parbat is one of great tectonic disturbance caused during various phases of Himalayan uplift, as evidenced by the extreme degree of regional or stress metamorphism of its rocks. The main strike of the country is from Kaghan, through eastern Chilas, to Bunji in a north-easterly direction, with a pronounced general inclination of the foliation-planes to the north-west. This dip is isoclinal, due to the inversion of imbricated systems of compressed and puckered folds, severed by many thrust and shear planes.

The syntaxial angle of the north-west Himalaya.

The lofty *massif* of gneissic rocks, comprising Nanga Parbat and the associated group of peaks, occupies a pivotal position with respect to the loop-like bend of the strike which takes place at this point in the central axis of the north-west Himalaya. Through Kaghan, Babusar and the Bunar valley of Chilas, the Himalayan strike is one unswerving definite N. E.—S. W. trend-line. All the mountain ranges of that district reveal this dominant tectonic feature in an unmistakable manner. A broad belt of mountains to the north of Gilgit have an almost exactly E.—W. strike. The strike of the region to the east of Nanga Parbat, though not so definite at first in the tract between Bunji and Astor, trends in the main in the opposite direction, *i.e.*, N. W.—S. E. South of Astor this becomes the dominant strike of the Himalaya for the whole width of the mountains from the water-shed line to the outermost foot-hills. The syntaxial angle of the north-west Himalaya between Hazara and Kashmir has already been discussed in another paper [1] where the view is expressed that the Himalayan geosyncline has been bent round a triangular promontory of the Indian Peninsular horst. Structurally as well as stratigraphically, the Hazara mountains are a direct continuation of the Kashmir mountains along one bent axis, an essential geological continuity being preserved throughout.

[1] D. N. Wadia: Syntaxis of the N. W. Himalaya, its Rocks, Tectonics and Orogeny. *Rec. Geol. Surv. Ind.*, LXV, p. 189, (1931).

In 1907 Sir Sidney Burrard, while discussing the western termination of the Great Himalaya range, remarked:

'To the casual observer the Punjab Himalaya appears to terminate suddenly at the Indus at the gigantic cone of Nanga Parbat and even trigonometrical observations have failed to indicate the course of the great range beyond the Indus.[1]'

and further:

'Trigonometrical surveyors have not been able to trace by means of heights the continuation of the Great Himalayan axis beyond the Indus and the problem will not be solved without a geological survey.[2]'

Geological investigation of the region to the west and south-west of Nanga Parbat show that whilst it is correct to say that the Great Himalayan range does not extend beyond the Indus, yet it cannot be regarded as terminating in Nanga Parbat. Instead, the fold-axes are bent abruptly to the south-west through Kohistan and North-East Hazara, and the Himalaya may be said to terminate as an orographical unit in the hills to the east of Campbellpore.

The same acute flexure of the geological trend-lines has been observed in the region to the north of Gilgit by Hayden, who confirms the previous observations of the Russian geologist Ivanow, the contemporary of Stoliczka. Hayden gives a clear account of the bend of the strike of this region from the S. W.—N. E. direction in upper Chitral to a consistently E.—W. line in the Pamirs and a further decided bend to a S. E.—N. W. direction eastwards of the Pamirs.[3] In all this extent, as in the area to the south of Nanga Parbat, the strike of the rocks is frequently in general conformity with the trend of the mountain ranges.

Reference may here be made to the important work of Prof. D. I. Mushketov in the trans-Pamirs region of Ferghana regarding the disposition of the trend-lines still further to the north.[4]

VI. THE CLIMBING OF NANGA PARBAT.

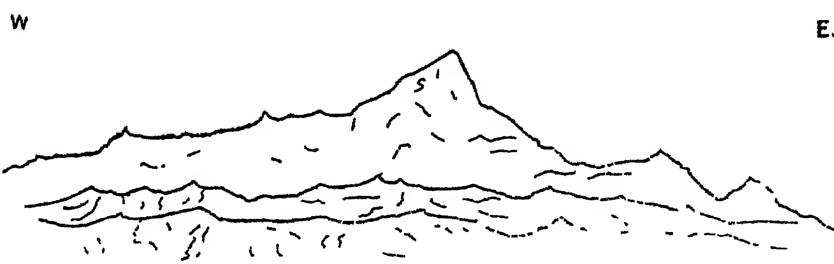
Possibility of climbing Nanga Parbat.

Since Mummery's classic venture in 1895, which ended in the tragic deaths of himself and of his two Gurkha companions on their way to the col leading to the Rakhiot glacier from the Diamirai side,[5] no attempt has been made to climb this mountain. The stupendous

[1] Geography and Geology of the Himalaya Mountains and Tibet, p. 79, (1907).
[2] *Ibid.*, p. 80.
[3] *Rec. Geol. Surv. Ind.*, XLV, pp. 273 and 320, (1915).
[4] Geological Map of East Ferghana, Turkestan, Leningrad, (1928); and The Structure of Asia, pp. 11 and 177, London, (1929) by Prof. J. W. Gregory.
[5] The Passing of Mummery: General C. G. Bruce, *Himalayan Journal*, Vol. III, p. 11, (1931).

cliffs of the south face will for long remain unconquered, and Mummery's experience has proved the difficulties of the west and north-western slopes from the Buner valley. The possibilities of the north and north-east side remain to be tested, and these perhaps offer better chances to climbers, because of less steep declivities above the snow-line and a uniform spread of snow and glacial ice covering up the extraordinary ruggedness of the slopes strewn with enormous gneiss blocks. The present writer has been nowhere within 11,000 feet of the summit, but from observation of these slopes from several points, the flanks, or the [illegible] of the narrow rock-ridges separating the large number of branching *couloirs*, draining the deep bay-like recess in the north flank of the *massif*, appear to him less impossible than the desperate Diamirai and Mazeno slopes.

It seems unlikely that any considerable additions to our knowledge of the geology of Nanga Parbat will result from an ascent of this peak, but a great deal of detailed work remains to be done on the petrography of the crystalline complexes of contiguous areas, on their analysis into their various component units, and on the study of the intricate injection phenomena displayed in them. These problems may have a bearing on the tectonics of this most important mountain plexus of the north-west Himalaya. This note, based on two traverses during brief seasons in 1930 and 1931, has been written in order to place on record certain broad facts of the geology of this interesting region—a region that promises to attract in the near future parties of climbers and tourists—and to help future investigators in their more detailed and intensive studies with the data obtained from previous work in neighbouring regions.



Text-fig. 1.—Sketch of outline of Nanga Parbat from the south, as seen from Rajdhiangan (11,900 feet), rising over ranges of 17,000 feet mean altitude.

VII. PETROLOGICAL NOTES.

Petrological examination of the more typical rocks collected from the area under description shows that they belong to the following three main groups:—

(1) Granites.
(2) Epidiorites, uralitised gabbro, serpentine.
(3) Para-gneisses and -schists, granulite, marble.

GRANITES.

1. Hornblende-granite: Locality—Chillum (35° 5′: 75° 6′). Fine to medium-grained normal granite with square orthoclase phenocrysts; varies in acidity, some types containing as much quartz as felspar; others contain less quartz and are crowded with large plates of deeply dichroic, green hornblende (black in hand-specimens). The rock is usually fresh, with unaltered felspars, mainly orthoclase, with a small proportion of oligoclase and microcline. Accessories—sphene, apatite, orthite and magnetite. Granophyric structure is common. This granite is found penetrating the epidiorites, serpentine, as well as the Panjal volcanic series.

2. Biotite-granite: Locality—the higher parts of Nanga Parbat; Hattu Pir; Gilgit; many veins near Partab Pul. This is a normal biotite-granite, porphyritic or schistose (with 'augen' structure), according to conditions of occurrence. Quartz abundant, muscovite is not common; varying proportion of plagioclases, usually microcline. Biotite is deeply coloured. The following accessories are common; apatite, zircon, sphene, magnetite, schorl, orthite, garnet. Petrographically, this rock strongly resembles the gneissic granite of Kazi Nag, the Pir Panjal, Dalhousie and Hazara; it is the 'Central gneiss' of Stoliczka and of McMahon.

This granite occurs largely in the central part of Nanga Parbat, the summit of the mountain being chiefly constituted of this rock; it is strongly foliated and is granulitic in structure, resembling in external aspect the biotite-gneiss described below.

3. Muscovite-granite: Localities—Parri; Leychar. This granite is more acid than the preceding type, with black tourmaline as a frequent accessory. It is not a common type.

4. Aplitic and pegmatitic modifications of these granites are common; they do not call for any special petrographic notice; they

are generally poor in accessory minerals, except garnet, schorl, muscovite and biotite, the latter sometimes occur in crystals four and five inches long.

EPIDIORITES.

1. Diorite: Locality—Ramghat; Maikial; and some cliffs opposite Astor. Some of these rocks, which appear to be typical diorites in hand-specimens, may be only the more basic varieties of hornblende-granite, while others are probably completely altered dolerites, whose pyroxene has been uralitised to hornblende. Rocks of this description are rather common. Free quartz is present in some specimens which are of light colour; the darker variety (a handsome brown, from Gilgit) have no quartz. There is a small quantity of orthoclase among the felspars. The hornblende is compact, brown, in idiomorphic plates, pleochroic in greens. Epidote, zoisite and magnetite are commonly present.

2. Altered dolerite (epidiorite). Specific gravity, 2·8—3·1. This is a very common rock throughout Chilas and Gilgit, occurring in bosses, stocks and numerous sills. Colour varies from light to dark green; the lighter varieties are easily mistaken for diorites. The augite is in most cases almost completely changed to compact brown, or green, deeply pleochroic hornblende in well-formed plates. In a few cases part of the augite is still left. Ophitic structure is visible in some sections; there is no olivine in any of the sections. Plagioclases are fresh in some cases, in others they are largely replaced either by granular zoisite or by an indefinite mineral aggregate. A very coarse epidiorite is very common between Bunar and Chilas. Epidote, garnet, clinozoisite and iron-ores are present in most sections.

3. Amphibolite: Locality—Garhkot (Gurikot); Gor; Astor. Specific gravity, 3·2. This rock occurs in thick sills intrusive into the Nanga Parbat gneiss. It consists of black, lustrous hornblende in crystals one to four inches in length. Plagioclases are almost absent. Iron-ores, garnets, zoisite and clinozoisite are accessories in variable amounts. In some hornblendites, garnets occur most plentifully.

4. Hornblende-schist. Locality—Thalichi. This is a schistose epidiorite consisting of thin, wisp-like, hornblende prisms set in a finely slaty or schistose aggregate of quartz and plagioclase grains. Accessories are garnet, epidote, zoisite and iron-ores. The field occurrence of this rock—in distorted phacolites, sills and dykes

in the gneiss—leaves no doubt about its origin from intrusive dolerite.

Epidote-schist occurs associated with these rocks in bands and intercalations and has doubtless originated from the extreme stress-metamorphism of doleritic rocks.

5. Pyroxenite: Locality—Godai. Specific gravity, 3·2. This specimen has three-fourths of its augite altered to hornblende. There is a fine-grained mixture of epidote, zoisite and small garnets, which has replaced some of the remaining augite. Specimens from Leychar and Pashwari show narrow rims of pyroxene surrounding the newly-formed hornblende crystals. The hornblende is rarely in the fibrous form of uralite.

6. Uralitised gabbro: Locality—Godai; Pashwari; Gilgit. This rock occurs as a segregation-product in the centres of dolerite masses as stocks and dykes. Moderately coarse-grained rock of dark colours. Basic plagioclases (labradorite) showing little or no alteration. A little quartz is present in four specimens. The hornblende resulting from uralitisation of augite is both of the light green, fibrous variety and of the brown compact variety, yet containing scraps of unchanged augite. In one specimen from Godai, biotite shares with hornblende the rôle of the chief mafic constituent. Apatite builds fairly large crystals; other accessories are magnetite and ilmenite.

7. Norite: Locality—Godai and Partabpul mountains. In this specimen about half of the augite is replaced by large crystals of schillerised hypersthene, pleochroic in pink colours. Some of these have a rim of fibrous uralite. Some biotite is present, but no olivine. The felspar is labradorite in large, clear crystals. In a specimen from Partabpul, Mr. W. D. West has detected the soda-microcline felspar anorthoclase.

8. Serpentine: Locality—Pashwari mountains; Mapnun; Babusar; Kalapani. The serpentines collected from these and other localities in Gilgit have one property in common, *viz.*, they are alteration-products of amphibole and not of olivine. It is a dark green rock of good lustre, resulting from the hydration of the ultra-basic segregations of gabbro bosses. In a specimen from the Pashwari mountains, the micro-section is full of small ragged scraps and wisps of both hornblende and augite. In other sections, pseudomorphs (bastite) of these minerals are seen. The accessories are carbonates and iron-ores (chromite), also small veins of chrysotile.

PARA-GNEISSES, ETC.

1. Banded biotite-gneiss. Locality—the mountains of Garhkot and Bunji; Hattu Pir above Doyan. This is a pale pink coloured, fine-grained, granulose gneiss (leptite), studded with beautiful pink garnets. Main components—quartz, acid felspars, biotite and almandine garnet, arranged in parallel bands due to alternation of layers of different composition. All the minerals except garnet appear to be xenoblastic and are quite fresh. Rutile is occasionally present. The quartz-felspar mosaic is crowded with prisms and blades of a colourless mineral which has been identified as kyanite. Sillimanite occurs in fine needles as well as stout prisms in some other rocks from the same locality. Large, blue, strap-like crystals of kyanite also occur in the biotite-gneiss to the south of Nanga Parbat.

This rock, together with those described below, occurs on the lower slopes of Nanga Parbat, generally below the level of the Rupal glacier; it is extensively permeated by the biotite-granite described above (p. 230). It is essentially a pelite-gneiss, resulting from the plutonic metamorphism of Salkhala sediments.

2. Quartz-, mica-, and graphite-schists. Localities—same as above. Finely foliated, wavy, thoroughly crystalline schists alternating with the gneiss just described. Biotite-schists are the most common of these. Very few secondary minerals are developed, except garnet; occasionally sillimanite and cordierite are noticed. Crystalline, flaky graphite is very prominent at some places, *e.g.*, near Babusar pass, though its percentage composition is never so high as to be of economic importance.

3. Marble, crystalline limestone. Locality—cliffs above Thalichi; Tarshing; Bunar valley; etc. Occurs in inter-foliated bands, lenticles or in thick beds in the schists. Some varieties are pure, white, saccharoidal marble (80-90 per cent. $CaCO_3$), others are grey-coloured, fine-grained and generally fœtid when struck. A large number of secondary calc-silicates are formed, among other new minerals, *e.g.*, micas (paragonite, sericite), felspars, hexagonal flakes of graphite, garnets, forsterite, tremolite, diopside, vesuvianite. In some specimens from the Indus bed near Chilas, a good deal of magnetite and pyrite occur; chalcopyrite is sometimes found.

4. Calc-schists and granulites. These highly schistose or granulose rocks are interbedded with the marble and represent the more impure metamorphosed limestone rocks. They are crowded with

secondary lime-minerals, besides newly-formed quartz, felspar, and mica. At some places, they are full of large garnets (as big as cherries), hornblende, etc.

5. Slate, phyllite and hornfels. Locality— south east of Gilgit; the Kamri pass. These are rocks with a pelitic foundation and some of them still retain the original lamination and slaty cleavage, where the dynamo-thermal metamorphism, which has affected the rest of the area, has for some reasons not been sufficiently intense locally. The more altered phyllites and hornfelses consist of a granoblastic aggregate of quartz, felspar, biotite with small pin head garnets.

EXPLANATION OF PLATES.

PLATE 4, Fig. 1. Nanga Parbat range as viewed from Bunji. A terrace of Indus gravels in the foreground.

Fig. 2. The Great Himalaya range from Burzil valley; the rocks are hornblende-granite with dolerite and epidiorite intrusions.

PLATE 5, Fig. 1. The Bunji oasis. Wind-blown sand capping two gravel-terraces at different levels on the Indus banks.

Fig. 2. The Indus at Partabpul. The rocks are dark epidiorites with veins of granite Note the apparent stratification effect of these veins in the mountains in the background.

PLATE 6.—Section across Nanga Parbat *massif* from the Indus river in Chilas to the Rupal valley in Astor.

PLATE 7.—Geological map of Nanga Parbat area and adjoining portions of Chilas, Gilgit district, Kashmir. (Scale 1 inch=4 miles.)

ON SOME FOSSIL PLANTS FROM THE PARSORA STAGE, REWA. BY A. C. SEWARD, SC.D., F.R.S., CAMBRIDGE. (With Plates 8 and 9.)

INTRODUCTION.

The fossils described in this paper were sent to me for examination by the Director, Geological Survey of India, and I take this opportunity of thanking him for giving me an opportunity of making a slight contribution to our knowledge of a flora of unusual interest.

The specimens were collected by Mr. N. K. N. Aiyengar Field Collector, Geological Survey of India, in a micaceous, ferruginous sandstone at the village of Chicharia (23° 31′ : 81° 12′) in Rewa State, Central India.

DESCRIPTION OF THE PARSORA SPECIMENS.

Plate 8. This, the largest specimen, has a relatively broad axis (7-9 mm.) characterized by a tuberculate surface recalling the rachis of *Lepidopteris* as figured by Antevs[1], though the preservation does not enable one to determine with certainty the structural origin of this feature. On magnification, the outlines of epidermal cells are clearly visible, but no definite evidence of ramental scales can be detected: it may be that the epidermal cells formed protuberances and not actual scales. The rachis is divided into two approximately parallel arms of equal breadth, and each arm gives off pinnae or large pinnules at a wide angle. The pinnae on the left-hand side have a stout axis bearing short, broad pinnules, some of which are almost orbicular; they are attached by a broad base and traversed by spreading veins without a midrib. The surface of some of the pinnules is finely tuberculate, but whether this is caused by epidermal hairs or small protuberances cannot be determined. The uppermost, lobed pinnule lying, no doubt, in

[1] Antevs, K. svenska. Vetensk Akad. Handl., Bd. 51, No. 7, (1914).

its original position on the right-hand arm of the rachis, does not show any clearly defined midrib, though in the basal part of the lamina the veins converge into a central strand. The venation is relatively coarse.

This specimen is clearly part of a much larger frond which probably forked more than once. It agrees closely with some of the large fossils from the Hawkesbury series of New South Wales, included by Feistmantel[1] in *Thinnfeldia odontopteroides* (Morris).

Plate 9, fig. 1. This is part of an incomplete pinna; the lamina is dissected into short and broadly rounded segments not completely free, in which the venation is clearly seen. There can be no doubt of the specific identity of this pinna and the larger specimen shown in Plate 8.

Plate 9, fig. 2. The preservation of this piece is less satisfactory. A broad axis bears alternate linear pinnae with rounded pinnules showing numerous, slightly divergent veins. Both on the axes and laminae can be seen traces of the tuberculate character, described above. My belief is that these small pinnae were borne on a large frond which in the lower part bore pinnae like those shown in Plate 8 and Plate 9, fig. 1.

It is noteworthy that some pieces of fronds from Parsora, which Feistmantel[2] figured as *Thinnfeldia odontopteroides cf.* Feist., agree closely with the present specimen and are, in all probability, specifically identical with it.

Plate 9, fig. 3. This fragment, with clearly preserved veins, is probably a piece of the same species of frond as that to which the larger specimens are assigned.

The specimens, so far described, are referred to a new species, *Thinnfeldia sahnii,* which it is a pleasure to name after my friend, Professor Sahni, who has added greatly to our knowledge of the Gondwanaland flora. The species, which is more fully discussed later, may be defined as follows:—

> Fronds reaching a large size, probably several feet in length; rachis forked into approximately equal, slightly divergent arms. On the main rachis and the branches of forks are borne linear pinnae and occasionally separate pinnules. The rachis and its branches have a tuberculate surface.

[1] Feistmantel, *Mem. Geol. Surv. N. S. W., Palaeont.*, No. 3, Pls. XXIV, XXV, (1890).
[2] Feistmantel, *Pal. Ind.*, Ser. XII, Vol. IV, pt. 1, Pl. VIII, figs. 4, 6, 7, (1882).

The pinnules are relatively thick and finely tuberculate; short and broad, entire or lobed, attached by a broad base; for the most part without a midrib and characterized by spreading, forked veins. The venation is comparatively coarse (the veins are approximately 0·5 mm. apart). Only sterile examples are known. In habit; the fronds resemble *Thinnfeldia*—including *Dicroidium*, *Danaeopsis hughesi* of Feistmantel—and other form-genera such as *Odontopteris*, *Callipteris*, etc.: in all probability they are the fronds of a Pteridosperm.

Thinnfeldia sp. (See also p. 41.)

Plate 9, fig. 4. Before discussing the probable nature of the species so far described, a brief account may be given of another Parsora specimen which is believed to be closely related to *Thinnfeldia sahnii*, though not specifically identical with it. The drawing shows only a portion of the actual specimen. which is 12·5 cm. long. A broad, imperfectly preserved axis, on which traces can be detected of a superficial pattern similar to that on *Thinnfeldia sahnii*, bears two rows of crowded, broadly linear and obtuse pinnules. There is a clearly defined midrib: the lateral veins are rather far apart and given off at an acute angle. The preservation of the pinnules is very imperfect, though a tendency of the lamina to form oblique folds parallel to the veins indicates that the ultimate segments were fairly thick and leathery.

It may be noted here that some fragments from Parsora, figured by Feistmantel as *Asplenium whitbyense*,[1] may be specifically identical with the large example shown in Plate 9, fig. 4.

Having regard to the incomplete state of this specimen. I refrain from the use of a specific name.

One of the impressions, K. 25·517 in the Chicharia collection in the same red sandstone as that in which the figured specimens were found, though too indistinct and imperfect to be determined or satisfactorily illustrated, is interesting because of its resemblance to a species described by Zalessky[2] as *Callipteris uralensis* from the Permian of Angaraland.

[1] Feistmantel, *op. cit.*, Pl. VIII, figs. 2, 3, (1882).

[2] Zalessky, *Mém. Com. géol. Leningrad*, Livr. 176, Pl. V, (1927).

THE AFFINITIES OF THE PARSORA PLANTS.

Plate 8 and Plate 9, figs. 1-7. We will first compare the fronds for which the name *Thinnfeldia sahnii* is proposed with those of *Danaeopsis hughesi*, a species founded by Feistmantel[1] on specimens from Parsora, which he described as intermediate between *Danaeopsis marantacea*, Heer, and *D. rajmahalensis*, Feist., though closer to the former. The fronds of *Danaeopsis hughesi*, as the drawings in Feistmantel's memoir[2] on the Rewa plants show, must have reached a considerable size; a forked rachis, which occasionally shows traces of superficial tuberculation, bears long and comparatively broad pinnae which are usually entire. On a few of the figured specimens, there are some relatively short pinnules comparable with those on the right-hand arm of the example reproduced in Plate 8. It would, however, seem unlikely, in view of the large number of specimens that have been figured, that the range in size and shape of the pinnae or pinnules was great enough to include the present forms. On the other hand, the resemblances are such as clearly indicate close affinity.

It is now generally agreed that the generic name *Danaeopsis* must be abandoned for the Indian fronds; they afford no evidence whatever of relationship to *Danaea* or other Marattiaceous ferns, nor can they be included in *Danaeopsis* as represented by the type-species, *D. marantacea* (Presl.). Two other names have been proposed. Halle[3], with some hesitation, adopts Lesquereux's *Protoblechnum*, a misleading name, because of implied affinity to the Polypodiaceous genus *Blechnum*. Moreover, the Chinese Permian specimens for which *Protoblechnum* was primarily used apparently differ from the Indian fronds in the lack of bifurcation of the main axis, a character to which I am inclined to attach importance. Though Halle's Chinese species resembles *Danaeopsis hughesi* in the form of the pinnules, it is very doubtful if the two are generically the same. The second substitution for *Danaeopsis* is the generic name *Supaia*, which was recently proposed by Dr. David White[4] and used by him in a very comprehensive sense. The choice of a generic name for this widespread Gondwanaland species is by no means easy. An objection to *Supaia* is that its author

[1] Feistmantel, *Rec. Geol. Surv. Ind.*, XIII, p. 188, (1880).
[2] Feistmantel, *Pal. Ind.*, Ser. XII, Vol. IV, pt. 1, (1882).
[3] Halle, *Palaeont. Sinica*, Ser. A, Vol. II, Fasc. 1, p. 131, (1927).
[4] White, *Pub. Carnegie Instn. Washington*, No. 405, p. 34, etc., (1929).

regards it in the light of a group-designation, including in it specimens which might well be assigned to *Thinnfeldia*, *Dicroidium*, or some other genera. In the absence of data afforded by cuticles, reproductive organs or other useful taxonomic guides, one cannot hope to produce a satisfactory diagnosis of a form-genus which, it is practically certain, comprises more than one genus in the strict sense and many different species.

The position is this: *Danaeopsis hughesi* and the species now named *Thinnfeldia sahnii* are almost certainly two species of one genus; the latter agrees closely with some of the large fronds which it is customary to refer to *Thinnfeldia* or, on the part of some authors, to *Dicroidium*. The species *Danaeopsis hughesi*, considered by itself, would hardly be placed in *Thinnfeldia*. It is interesting to find that several years ago Prof. Sahni[1] said that *Danaeopsis hughesi* by its whole appearance struck him 'as being only a giant *Thinnfeldia*'. Pending the discovery of specimens, well enough preserved to supply information on the structure of the epidermis, I venture to apply to the fronds previously known as *Danaeopsis hughesi* and those now described the generic name *Thinnfeldia*.

Opinions differ on the value of the characters on which some authors employ the term *Dicroidium* in preference to *Thinnfeldia*; it may be that as knowledge increases the adoption of *Dicroidium* will become general; but for the present, *Thinnfeldia* is retained and used without prejudice as a provisional designation rather than as denoting a generic type which, on the data at present available, cannot be satisfactorily defined.

We pass now to *Odontopteris;* in the forking of the rachis, the occurrence of pinnules on the main axis, and the absence of a midrib, the fronds of this late Palæozoic genus agree generally with those from Parsora. The excellent photographs of specimens described by Halle[2] from Shansi as *Odontopteris subcrenulata* (Rost) Zeill. show a fairly close resemblance to the Indian species; a difference is the finer venation and, presumably, the thinner pinnules of *Odontopteris*. Another Chinese plant, *Odontopteris* (*Dicroidium* ?) *orbicularis*, as it is named by Halle, is very similar in the form of pinnae and pinnules to the specimens from Parsora referred by Feistmantel to *Thinnfeldia odontopteroides* and the example reproduced in Plate 9, fig. 2. In a footnote referring to the use

[1] Sahni, *Proc. As. Soc. Beng.* N. S., Vol. XVII, p. clii, (1922).
[2] Halle. *op. cit.*, p. 114, (1927).

of the name *Dicroidium* by Gothan and Antevs, Halle says—' I am yet inclined to keep most of the forms of *Dicroidium* separated from *Thinnfeldia*....the distinction between *Thinnfeldia* and *Dicroidium* should, in my opinion, be based chiefly on the venation, which is generally characterized by the occurrence of a midrib in *Thinnfeldia*, while it is odontopteroid in *Dicroidium*.'[1] It may be in accord with a natural classification to employ these two generic names, but the difficulty is that as yet we have no satisfactory criteria to guide us. It is true that many forms included in *Thinnfeldia* are characterized by pinnules with a midrib; on the other hand, the pinnules of *Danaeopsis hughesi* possess pinnules with a midrib.

The most recent account of fossil fronds resembling the Parsora species is by Dr. David White in his ' Flora of the Hermit Shales of Arizona '.[2] He draws attention to the difficulty of defining the characters of several form-genera, which are almost certainly fronds of Pteridosperms, and are probably closely related members of one group. Among these are *Danaeopsis hughesi*, *Odontopteris*, *Callipteris*, *Thinnfeldia* and *Dicroidium*. In order to meet this difficulty Dr. White institutes a new generic name *Supaia*, including in it fronds having a once-bifurcate rachis, each arm of the rachis being pinnate or pinnatifid, and pinnules varying from Alethopteroid to Neuropteroid. He restricts the term *Dicroidium* to bipinnate, Odontopteroid fronds of ' *Thinnfeldia* '.

It is, I venture to think, very doubtful if the presence or absence of a midrib can be used as a trustworthy distinguishing feature. The Parsora fronds described by Feistmantel bear large pinnules with a midrib; those now described from the same locality have pinnules for the most part of the Odontopteroid form.

In view of the obvious resemblances, indicative of close relationship between the two sets of specimens, the employment of one generic name is essential.

For the present, I adopt the generic name *Thinnfeldia* for the fronds previously known as *Danaeopsis hughesi* and those now referred to a new species.

It is with some hesitation that a new specific name is proposed; there is a very close resemblance between large specimens from New South Wales, which Feistmantel included in the species

[1] Halle, *op. cit.*, pp. 116, 117, (1927).
[2] White, *op. cit.*, (1929).

Thinnfeldia odontopteroides (Morr.), and that reproduced in Plate 8. Moreover, the much smaller example shown in Plate 9, fig. 2, agrees closely with some of the smaller specimens figured by Feistmantel. Gothan[1] transferred the larger forms described by Feistmantel to a new species, *Dicroidium feistmanteli*, though, as Antevs[2] admits, it is hardly possible to say definitely whether or not such separation is admissible. The name *Thinnfeldia feistmanteli*, Johnston, is applied by Walkom[3] to specimens from the Ipswich series of Queensland, believed to be identical with the New South Wales plant.

An identical form with comparatively large pinnules similar to those of the Parsora specimen (Plate 8) is recorded from South Africa[4] as *Thinnfeldia odontopteroides*.

Though it is by no means certain that the fossils for which the name *Thinnfeldia sahnii* is proposed are specifically distinct from some of the incomplete fronds previously included in *Thinnfeldia odontopteroides* and *Thinnfeldia* (or *Dicroidium*) *feistmanteli*, it is, I think, preferable to adopt a distinctive name for the Parsora form. The branching of the rachis differs in some degree from the more open forking of most *Thinnfeldia* fronds; the pinnules tend to be more rounded and suborbicular, and the tuberculate surface of the axes, and it would seem also of the pinnules, is a feature which is not noticeable in most Thinnfeldias.

Thinnfeldia sp.

Plate 9, fig. 4. As already stated, it is probable that this specimen is part of a Pteridosperm frond which may be generically identical with *Thinnfeldia sahnii*. It resembles specimens referred to *Alethopteris*, *Callipteris*, *Callipteridium*, and *Thinnfeldia*. A similar form is described by du Toit[5] from the Beaufort beds of South Africa as *Callipteridium africanum*; the lamina of the pinnules shows the oblique folding which is a character of the Parsora specimen. Many other comparisons might be made with Gondwanaland species and with some of the species from the Kusnezk flora figured by Zalessky.[6]

[1] Gothan, *Abh. Naturhist. Ges. Nuremberg*, XIX, Bd. 3, (1912).
[2] Antevs, *K. svenska. Vetensk Akad. Handl.*, Bd. 51, No. 6, p. 3, (1914).
[3] Walkom, *Pub. Geol. Surv. Queensl.*, No. 257, (1917).
[4] Seward, *Quart. Journ. Geol. Soc.*, Vol. 64, p. 83; Pl. V, fig. 1, (1908)
[5] Du Toit, *Ann. S. Afr. Mus.*, Vol. XXII, pt. 2, Pls. XXV, XXVI, (1927).
[6] Zalessky, *Mém. Com. géol. Leningrad*, Livr. 174, (1918).

My view is that many of the Pteridosperm fronds, unquestionably varying over a wide range, which are characteristic of Permian and slightly younger floras, cannot be distributed among species that it is possible satisfactorily to define. Moreover, I agree with White that the drier conditions which prevailed towards the close of the Palæozoic era are reflected in the habit and in the abundance of a group of xerophytic plants—many of which he includes in *Supaia*—which we cannot at present assign with confidence to clearly definable genera. I have little doubt that the specimen represented in Plate 9, fig. 4, is a piece of a frond closely allied to *Thinnfeldia,* using that name in a wide sense as including *Dicroidium.*

AGE OF THE PARSORA SERIES.

Prof. Sahni[1] has called attention to the presence of two sets of plants in the Parsora beds, one set indicative of a Triassic flora and another, a much smaller group, forming a connecting link with younger floras. It may well be that the *Cladophlebis* species to which Sahni refers is a *Thinnfeldia.* It is in the highest degree probable that the Parsora flora is not younger than Lower Triassic, and the most abundant species lead me to believe that it agrees more closely with late Permian floras of the northern hemisphere than with any Mesozoic floras.

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EXPLANATION OF PLATES.

PLATE 8. *Thinnfeldia sahnii*, sp. nov.—(natural size) (G. S. I. Type No. 15.469).

PLATE 9, Fig. 1. *Thinnfeldia sahnii*, sp. nov.—Part of a pinna (natural size (G. S. I. Type No. 15.470).

PLATE 9, Fig. 2. *Thinnfeldia sahnii*, sp. nov—Small pinnae (natural size) (G. S. I. Type No. 15.471).

PLATE 9, Fig. 3. *Thinnfeldia sahnii*, sp. nov—(natural size) (G. S. I. Type No. 15.472).

PLATE 9, Fig. 4. *Thinnfeldia* sp.—(natural size) (G. S. I. Type No. 15.473).

A NOTE ON THE SWA EARTHQUAKE OF AUGUST 8TH, 1929. BY J. COGGIN BROWN, O.B.E., D.SC., F.G.S., *Superintendent, Geological Survey of India.*

INTRODUCTION

The Swa earthquake of August 8th, 1929, was the first member of a series of major earthquakes the epicentra of which are distributed in a linear fashion in a narrow belt of country which runs approximately north and south from some unknown point in the Gulf of Martaban, across the plains of Pegu and through the valleys of the Sittang and Samon, to a point in the Irrawaddy valley near Shwebo and perhaps further north still. The land course of this belt is at least 450 miles long. It includes both the great boundary fault separating the crystalline and Palæozoic rocks of the Shan States and Karen hills from the Tertiary deposits of the Burmese plains, and the associated parallel faults which are believed to exist at short distances to the west of the boundary fault, itself actually within the Tertiaries.

The connection between the Swa earthquake, the Pegu disaster of May 5th, 1930, the Pado earthquakes of July to December, 1930, and the Pyu disaster of December 4th, 1930, has already been traced,[1] while in a forthcoming report the detailed record of later shocks has been continued up to the early months of 1932.[2] Throughout the year 1931, earthquakes were of very frequent occurrence and occasional severity in this zone, the more important shocks being those of the Daiku-Paungdawthi region on May 4th, Pegu on May 16th, Amherst on August 6th to 15th, Pyinmana on August 10th, Kyaukse on August 19th, and Pyu on September 16th and 23rd. Disturbances which were reported from all localities between Pyuntaza and Toungoo on January 5th, and from places between Pyu and to the north of Toungoo on January 13th, 1932 are unpleasant reminders that stability has not yet been attained.

No apology seems to be necessary, therefore, for placing on permanent record such details as are available of this earthquake.

[1] 'A Preliminary Note on the Pegu Earthquake of May 5th, 1930,' by J. Coggin Brown, P. Leicester and H. L. Chhibber, *Rec. Geol. Surv. Ind.*, LXV, pp. 267-268, (1931)

[2] 'Earthquakes of Burma during 1931, by J. Coggin Brown. Appendix to 'The Pyu Earthquakes of December 3rd and 4th, 1930,' by J. Coggin Brown and P. Leicester, *Mem. Geol. Surv. Ind.*, LXII, pt. 1, (*in the press*).

It was in fact a herald of the recrudescence of violent seismic activity in a region which, as far as the present generation is concerned, has enjoyed tranquillity, but which both history and tradition lead the student to suspect of having suffered from similar visitations in a more remote past.

Swa is a small town situated about latitude 19° 13′ and longitude 96° 14′ in the northern part of the Toungoo district, on the main line of the Burma Railways, 192 miles from Rangoon. It lies near the western edge of the Sittang plain, on the banks of the Swa *chaung*, a tributary to the Sittang river, flowing from the Pegu Yomas, which rise steeply from the plain a short distance to the west of the town. Rocks of Tertiary age build up the Yomas, but on the eastern side of the plain some 15 miles away, the crystalline rocks of the Karen hills rise, and somewhere under the alluvium lies the boundary fault. Fortunately for the inhabitants of Swa, their houses, like those of most other Burmese towns, are mainly of light timber construction and are practically earthquake proof. At Swa, however, Messrs. Steel Bros. & Co., Ltd., possess a saw mill, which is connected by a railway with their timber depot in the forest to the north-west. Most of the damage caused by the earthquake was done to this railway, or rather to the metre-gauge portion of it which lies between Swa and Tindinyan, ten miles to the north-west.

The Geological Survey of India is indebted to the officers of this Company for their courtesy in supplying accounts of this quake.

ACCOUNTS FROM SWA.

In a letter dated the 9th August, 1929, Mr. H. W. Grey of Messrs. Steel Bros. & Co.'s Swa Agency, reported to the headquarters of his firm in Rangoon as follows :—

'A severe earthquake shock at 7-20 P.M. last night, followed by a succession of minor tremors, caused some damage to the brick casing of our boilers and broke a steam pipe. To-day has been spent in making repairs and examining shafting which appears to be in good order. I understand that the metre-gauge track has suffered very serious damage and will advise you of its extent to-morrow as soon as I can get in touch with Mr. Hunt. We have been very anxious all day about the fate of Rangoon and are greatly relieved by news just to hand that no shock was felt.'

Mr. L. G. Hunt's report is summarised below :—

The severe earthquake shock of the 8th instant did considerable damage to the metre-gauge track from the 4th mile to Tindinyan. Rail joints were pulled out,

breaking fish-plates and bolts. In places the track is twisted and bent. Culvert revetments have fallen in. Large cracks have formed on and alongside the track particularly at miles $4\frac{1}{2}$ and 5. A big fall of earth occurred in the cutting near Gonmingum level crossing and four bridges were badly damaged. The Zebyubin and Yeyayemyaung bridges (7 miles north-west of Swa) will have to be rebuilt. The latter is like a camel's back, having been pushed up about 2 feet in the centre, with the cross-pieces lifted from the piles. Two loaded trucks were lifted off the track and thrown on one side at Gyogon. Several cooly huts collapsed. There is a large crack in the Gyogon spur line, about 100 feet long and 5 feet deep in places, running parallel to the stream. No damage was done to the narrow-gauge line.

A note by Mr. R. M. Harrison Kidd, Superintending Engineer of the same firm, is summarised below:—

Cutting No. 22, about mile $4\frac{1}{2}$, is blocked. The track between $4\frac{1}{2}$ and 5 miles has been thrown badly out of alignment. At one place it is 15 inches out in a length of 50 feet. Fish-plates have been broken and bolts sheared at eight different places. The creepage at one place was $6\frac{1}{2}$ inches. Bad fissures have appeared at a number of places parallel to the track, especially between miles $4\frac{1}{2}$ and 5. In this vicinity the fissures also run diagonally under the track. At the worst place they are 6 inches wide and 4 to 5 feet deep. Cutting No. 26 collapsed. The revetment of the Kyathoung bridge was smashed. At the Kyathoung points, the track had sunk and was out of alignment. One of the longitudinal stringers was lifted off the tenon of the bridge at mile 6. The cutting at Zebyubyin fell in. The stringers of the Yeyayemyaung bridge were lifted bodily from the piles, moved sideways and brought to rest clear on the top of the post tenons. The upper structure of this bridge had to be completely dismantled and re-erected. The revetments of the bridges at Thanbo, Koko, Tinwah and Tindinyan collapsed. At the Gyogon siding, two loaded metre-gauge trucks were turned completely upside down.

Mr. G. C. Cheyne, River Training Expert, Public Works Department, gave the following information:—

'Bridge No. 306, Burma Railways, over the Swa Chaung. Of the main girders, one has moved $2\frac{1}{2}$ inches and the other $1\frac{1}{4}$ inches, a total displacement of $3\frac{3}{4}$ inches.'

Another account from a Swa resident stated that the shock was preceded by a deep rumbling sound and that the vibrations appeared to be from north to south. A brick wall was thrown down and the posts of sheds were loosened. Heavy furniture was moved about in the houses and in some cases knocked over. The first and most severe shock occurred at 7-30 P.M. and lasted about five seconds. Further slight shocks were felt throughout the night.

The Sub-Divisional Officer of Toungoo, in relating his experiences of the Pyu earthquakes of December 3rd and 4th, 1931, recalled the fact that the town of Thagaya was badly damaged in the Swa earthquake (Thagaya is four miles north of Swa).

REPORTS FROM OTHER PLACES.

The following telegram was received at the Geological Survey Office in Rangoon from Mr. W. E. V. Abraham, Geologist, Burmah Oil Co., Ltd., on August 9th, 1929 :—

Nyaunghla, Tharrawaddy and Okkan.

'Small earthquake felt at Nyaunghla last evening at half-past seven. Was felt more intensely at Tharrawaddy and Okkan about the same time.'

Nyaunghla is the residential station of the Burmah Oil Co., Ltd., near Yenangyaung. Tharrawaddy is the headquarters of the district of the same name and Okkan is a town in the Insein district, 12 miles to the south.

Tharrawaddy.

According to an account in the *Rangoon Gazette* of August 13th, 1929, an earthquake was felt at Tharrawaddy at 7-27 P.M., on August 8th. It caused hanging lamps to swing violently and clocks facing north and south to stop. No damage was caused to buildings.

Paungde.

The same newspaper stated that the shock was felt at the same time at Paungde in the Prome district, 61 miles N.N.W. of Tharrawaddy.

Pyinmana.

The Pyinmana correspondent of the *Rangoon Gazette* of August 19th, 1929, stated that a slight shock occurred there on July 25th which lasted a few seconds, while on August 8th, at about 7 P.M., a severe quake lasting over a minute was experienced.

Yamethin.

The Yamethin correspondent of the *Rangoon Times* of August 12th, 1929, wrote as follows :—

'The residents of Yamethin experienced two earthquake shocks one after the other on the night of the 8th inst., which lasted about three minutes and were rather severe. Wooden buildings commenced to sway and doors and windows rattled. In some houses the pictures on the walls were thrown to the ground. Others complained that certain of their possessions were broken.'

Bombay instrumental record.

The Associated Press of India reported that an earthquake of moderate intensity at its origin, about 1,500 miles away, was recorded by the Bombay seismograph at 18 hours 32 minutes on the 8th August.

CONCLUSIONS.

Judging from the damage to the metre-gauge railway, the epicentre of the earthquake lay about six miles to the north-west of

Swa, which, from such little geological evidence as is available, seems to point to the movement of a fault in the Tertiary rocks, more or less parallel to the boundary fault, rather than to action of the latter itself, as the cause of the disturbance. It is believed that many of the later members of the same family of earthquakes originated in the same way.

Collapse of huts.

The extensive and deep fissuring of the ground, buckling of railway lines, breaking of fish-plates, shearing of strong iron bolts, destruction of bridges and smashing of strong masonry revetments, indicate an intensity over the restricted epicentral tract of degree X on the Rossi-Forel scale. In Swa itself, an intensity of IX was probably reached; in the case of Pyinmana about 30 miles north, the details are insufficient to permit the allocation of a figure, but as far away as Yamethin, 83 miles to the north of Swa, the shock was still strong enough to sway buildings and to displace hanging objects. The intensity here is taken as between degrees VI and VII.

The Swa earthquake, though it did not affect so widely spread an area, shares many features besides a common origin with the Pegu, Pyu and other later shocks—its sudden occurrence without any premonitory foreshocks, its preceding noise, its short duration and its violence over a small epicentral area. In no common character, however, is this more apparent than in the manner in which the intensity died down or was damped out towards the west and south-west, compared with its greater endurance over longer distances to the north.

The two earthquakes, 'one after the other,' reported from Yamethin are normal phenomena and do not lead to the supposition of a double shock at the epicentre. They are due to the different velocities of travel of the longitudinal (P) and the transverse (S) waves in the upper layers of the earth's crust, which at a distance of 100 miles would, according to seismological authorities, result in the S waves arriving 19 seconds after the P waves.

APPENDIX.

The Rangoon Earthquake of September 6th, 1929.

To complete the list of known Burmese earthquakes in 1929, advantage is taken of the present occasion to record the occurrence of a slight earthquake at Rangoon at 9 hrs. 6 mins. 15 secs. A.M.,

Burma Standard Time, on September 6th, 1929. Earlier local shocks of this series, which originate in local lines of weakness below the deltaic alluvium and are not associated with the movements of the instable zone mentioned in this paper, occurred on January 14th and 15th of the same year.[1]

[1] 'The Rangoon Earthquakes of September and December, 1927,' by J. Coggin Brown, *Rec. Geol. Surv. Ind.*, LXII, p. 259.

NOTE ON AN OVERLAP IN THE NGAPE AREA, MINBU DISTRICT. BY E. L. G. CLEGG, B.SC., *Superintendent, Geological Survey of India.* (With Plate 10.)

INTRODUCTION.

In the Records of the Geological Survey of India, Volume XLI, pages 221-239, (1912), Dr. G. de P. Cotter has described the Pegu-Eocene succession of the Minbu district near Ngape. The isolated area described, which, as the late Mr. E. W. Vredenburg stated, forms the key to the Tertiary stratigraphy of Burma, was included in the sheet mapping carried out by me during the field seasons 1921-22 and 1922-23. During this period I was able to examine the area in detail, and the stratigraphical results obtained are presented to amplify those of Dr. Cotter, to whose paper this present note forms a supplement. I have included a description of the Yinshe-Manaung basin, west of Kyet-u-bok to the south, as the structure is analogous to that of Sabagyidan and helps to explain the anomalous stratigraphy of the area. The faults bounding the eastern flanks of the two synclines are probably connected and continue to the south.

Introduction.

GEOLOGY.

Sabagyidan.

With reference to the Ngape area, Dr. Cotter states :—

'At Sabagyidan village vertical and contorted beds are seen in the river section, and it is probable that a fault should be marked here. Whether there is a reduplication of the rocks exposed east of Sabagyidan or not, I am unable to say, but if this is not the case, the immense thickness of the Eocene is a difficult matter to explain.'

Detailed work in the area shows that Dr. Cotter's surmise of a duplication of some of the rocks is correct and that immediately west of the site of Sabagyidan village (the village no longer exists), a small, shallow syncline, $2\frac{1}{2}$ miles long, occurs on a N. W.—S. E. axis and is separated by strike faulting from the normal sequence to the east. On the south side of the Man river, the trough of the syncline is occupied by thick, massive limestones in which foramin-

ifera occur; on the north side, the limestones have either been denuded away or have never been present, but a conglomerate which underlies the limestones on the south side is seen also on the north bank of the *chaung*. It is fossiliferous and contains nummulites. This conglomerate dips due east at 30° under the pagoda immediately east of Thakutpin village, swings round to the east, to the north-east of the village, and then to the south-east, half a mile east by north of the same place. The dip increases along the strike until at the latter point it is at 80° south-west. A similar band is found almost vertical and striking N. W.—S. E., one furlong west of Hill 676, half a mile south by west of Myeni.

The conglomerate passes downwards into 50 to 100 feet of sandstones and these are underlain by Tabyin clays, characterised by calcareous lenticles showing cone-in-cone structure. Upwards, 200 to 300 feet of sandstones are found; but these sandstones are not very well seen owing to the thick soil cap on the north side of the Man and the talus slope of limestone detritus on the south side.

The conglomerate is of Pondaung sandstone age (Cotter's 'I' F. B.), and in the Sabagyidan limestone the foraminifera include *Lepidocyclina elephantina*, *Lepidocyclina* sp. and *Heterostegina* sp. As this is the association found in the limestone of the Padaung clays to the east and as *Lepidocyclina elephantina*, an abnormal form, has never, so far as I am aware, been known to occur in any formation other than the Lower Aquitanian, this limestone must be assigned to that horizon. It remains, therefore, to explain the fact that the sequence as seen in the Sabagyidan syncline is not more than 500 feet from the base of the Pondaung to the limestone horizon of the Padaung clays, whilst to the east, the same sequence is represented by not less than 5,000 feet of alternating strata.

Yinshe-Manaung area.

The Yinshe-Manaung basin lies to the west of the main Nwamataung range four miles S.S.E. of that of Sabagyidan. It is characterised by a duplication of the Kyet-u-bok—Tabingyo limestone band, which is found to the west; and the fauna of the band, a mixture of the species found in the 'G' band and the Kyet-u-bok band, confirms Dr. Cotter's correlation of the 'G' band with that of Kyet-u-bok.

The following fauna was obtained from it:—

Cardium thetkegyinensis, Cotter.
Cardium subfragile, Bottger.
Orthophragmina omphalus, Fritsch.

Nummulites obesa.
Operculina cf. *canalifera*, d'Arch.
Tellina (*Colpopagia*) *tazuvensis*, Cotter.
Athleta (*Volutospina*) *annandalei*, Vred.
Discocyclina papyracea, Boub., var. *javana*, Verb.
Gosavia humberti (d'Arch & Haime).
Corbula sp.
Chlamys sp.
Triton sp.
Chama sp.
Natica sp.
Orthophragmina sp. cf. *umbilicata*, Deprat.
Conus sp.
Turritella sp.
Orthophragmina sp.
Ficula sp.

This basin is also separated from the main sequence to the east by strike faulting, demarcated by a fault valley.

The fossiliferous limestone band is overlain by bluish to fawn, fine-grained sandstones, which lie almost horizontally in the centre of the basin. It is underlain by sandstones, generally fine-grained and of a fawn colour, reinforced by harder gritty and shelly bands, dipping into the basin from the west and south at from 25° to 30°.

These sandstones are underlain by clays (Tabyin-Laungshe shales) of the Paungyaung valley; but the thickness of the cotton soil capping tends to obscure the solid geology.

To the north of the main basin, outliers of the limestone band lie horizontally, capping the high ground one and 1½ miles respectively to the north-east of Padan.

In the main range below the Kyet-u-bok—Tabingyo horizon, approximately the same sequence is met as occurs east of the Saba-gyidan syncline further north, *i.e.*, from the Kyet-u-bok or 'G' band downwards:—

Main range east of the Yinshe-Manaung basin.

Shales.
Sandstones.
Shales with lenticular coal seams and oil seepages.
Massive sandstones.

These form the Yaw-Pondaung stage. Above the Kyet-u-bok band are alternating shales and sandstones, the former predominating.

This series passes right up to the Irrawaddy boundary and no limestones occur in it south of Padaung.

The eastern, normal monoclinal sequence has a thickness of about 5,000 feet from the base of the Pondaung to the Kyet-u-bok band, but that of the synclinal basin, in which the shale series with coal lenticles and oil seepages is completely cut out, is not more than 1,000 feet. Hence a structure is obtained analogous to that of Sabagyidan.

Sabagyidan and Yinshe-Manaung areas compared. Comparing the two areas we find :—

(1) Absence of the shale series with associated coal and oil in both basins.
(2) Absence of the 'G' or Kyet-u-bok band in the northern (Sabagyidan) basin and its presence in the southern (Yinshe-Manaung).
(3) Absence of the limestone band in the Padaung clays on both flanks of the main range south of Padaung.

Further, a section along a line through Kanni and Myegya, *i.e.*, at right angles to the strike, only one mile south of the Yinshe-Manaung basin, shows that shales predominate locally throughout all the Tertiary rocks from the basal conglomerates to the Irrawaddy series.

Two obvious explanations of the discrepancies in the thickness of the various strata of the synclines and of the main range are possible :—

(1) A lateral thinning in a westerly direction.
(2) Overlapping due to marine transgression.

The absence of the well-marked 'G' band of the main range in the Sabagyidan syncline and its presence in the Yinshe-Manaung basin, and the absence of the shale series with associated coal and oil in both basins, whilst rather condemning the theory of lateral thinning, provides all the evidence necessary for the support of overlap due to marine transgression. Whether this overlap was continuous from the Upper Eocene throughout the Shwezetaw into the Padaung clay age, or whether two separate local overlaps took place, it is rather difficult to say; but as the evidence from the Kanni-Myegya section shows that deeper water conditions prevailed and that a local deep probably existed south of the position of the

Yinshe-Manaung syncline during the Eocene, Oligocene and Miocene periods the most suitable interpretation appears to be that of an overlap from this area northwards and westwards owing to the gradual sinking of this local basin. The latter solution is the simpler as it involves the sinking of only one area ; whereas the former demands that of two contiguous areas separately, in succeeding epochs.

EXPLANATION OF PLATE.

PLATE 10.—Geological Map of the Southern End of the Nwamataung Range, Minbu district, Burma. Scale 1 inch = 4 miles.

MISCELLANEOUS NOTE.

Note on an Ammonite from Ramri Island.

So little is known of the Cretaceous deposits of Arakan, that the following fragmentary notes which I found amongst the papers of the late Mr. E. Vredenburg seem worth publishing.

Mr. Vredenburg has left on some odd sheets of paper material for the establishment of a new species of ammonite, namely *Acanthoceras daviesi.* The specimen cannot now be found, and the specific name is invalid, but it is important to note that an *Acanthoceras* has been found in the Cretaceous strata of Ramri Island. The specimen, it may be supposed, came into Mr. Vredenburg's hands through Mr. H. J. Davies, who was then in the employment of the Burmah Oil Company as a geologist.

Mr. Vredenburg says in the course of his notes :—

'This ammonite belongs to the group of *Acanthoceras coleroonense,* Stol.,[1] and is particularly closely related to *Acanthoceras footeanum.*[2] In the Ramri species the whorls are relatively lower than in *A. footeanum* ; originally the umbilicus in the Ramri species appears broader ; the ribs are slightly more crowded, and much coarser, so that the tuberculations, though more prominent, are much less individualised. The siphonal lobe is broader ; the first lateral lobe is situated more externally, that is, nearer the middle of the lateral surfaces, and consequently the second lateral lobe, instead of being internal to the umbilical tubercles as in *A. footeanum,* is external to it. These differences in the septal sutures are principally due to the difference in shape of the whorls. Otherwise, the sutures are of exactly the same type in both species, and, so far as can be judged from the preservation of the specimens, the degree of denticulation is the same.

'The solitary specimen of *Acanthoceras daviesi* is camerated only to a radius of (blank in MS), and it is therefore uncertain whether the Ramri ammonite ever reached the enormous dimensions of the south Indian species. The main feature, characteristic of the suture of both species, is the enormous width of the first lateral lobe, a character, which, under the present system of minute generic analysis, might be taken as sufficient for subgeneric separation.

'*Acanthoceras footeanum* occurs in the middle division of the Utatur beds, and is therefore typically Cenomanian in age. The other South Indian species of the group, *Acanthoceras coleroonense* occurs both in the lower Utatur ("Vraconnian" or passage beds between the Gault and the Cenomanian), and in the middle Utatur. So far as is known, the typical examples of the group of *Acanthoceras coleroonense* belong mainly to the Cenomanian, and this may be taken as the age of the beds containing *Acanthoceras daviesi.*'

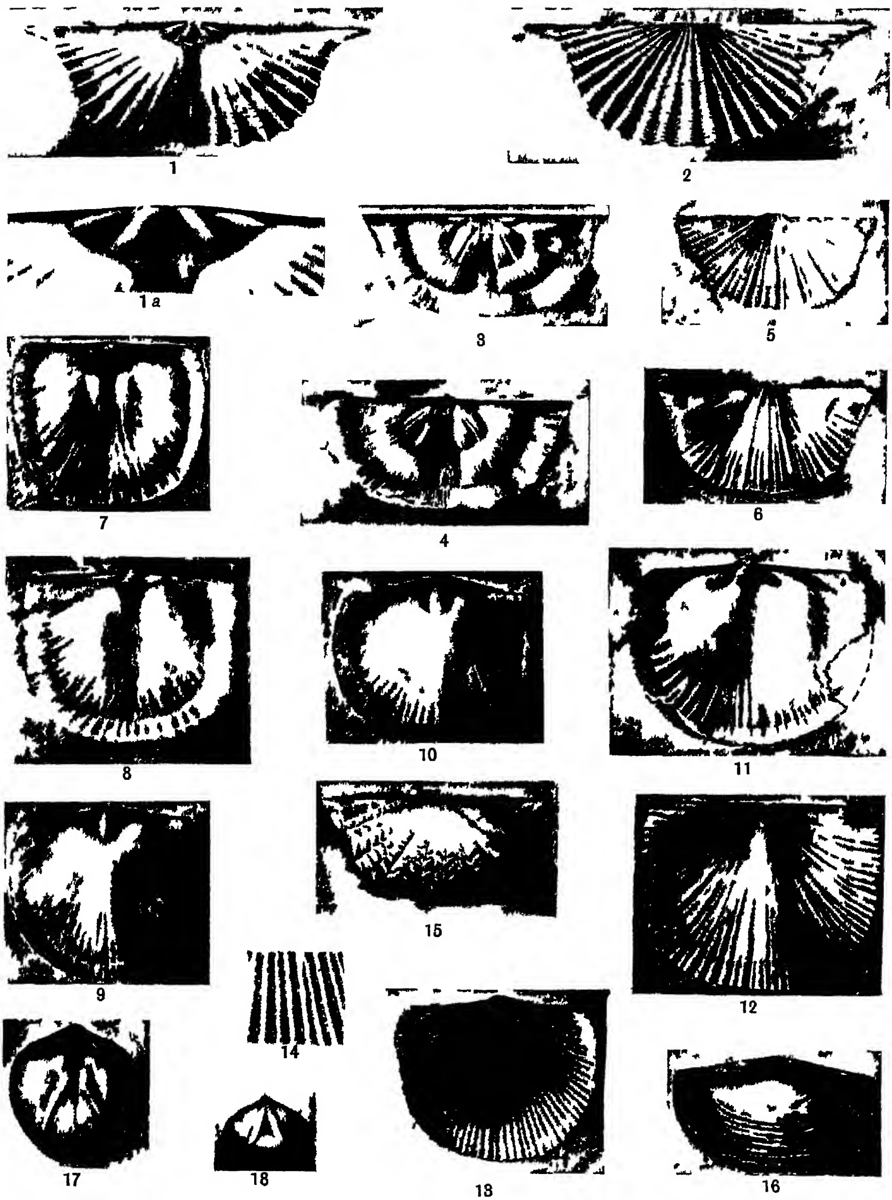
[1] *Pal. Ind.,* Ser. I—III, Vol. I, Pl. XXXVII, figs. 4-6.
[2] *Ibid.,* Pl. LII, figs. 1 and 2.

Eocene rocks are known from Ramri Island,[1] but the Upper Cretaceous has not been recorded. It would be interesting to know whether there is an unconformity between the Cenomanian and the Eocene in Ramri Island or not.

G. de P. Cotter.

[1] Sir E. H. Pascoe, *Mem. Geol. Surv. Ind.*, XL, pt. 1, p. 183, (1912).

MGIPC—M—VIII-4-5—20-1-33—850.



LOWER PALÆOZOIC FOSSILS FROM THE SOUTHERN SHAN STATES

E T TALBOT, *del*

G S I Calcutta

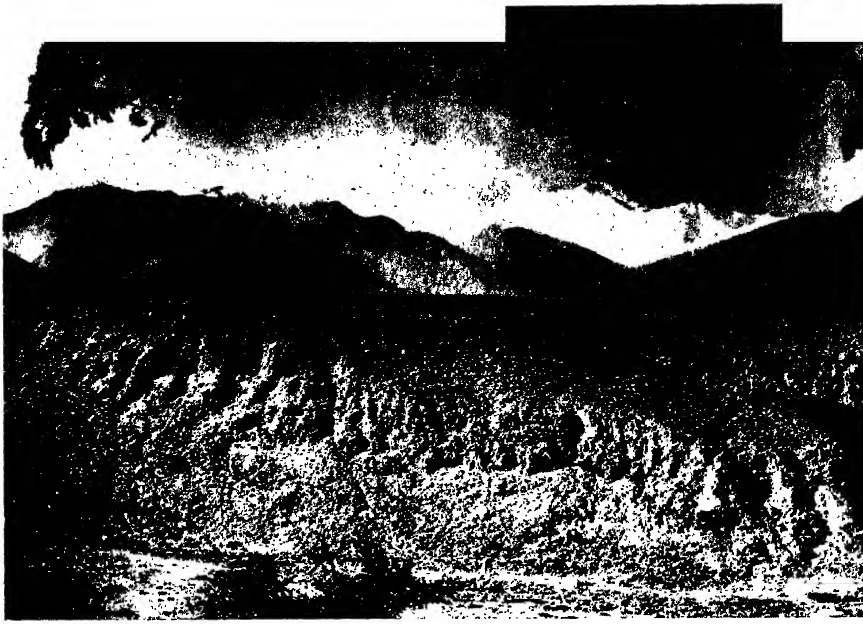


FIG. 1. VIEW OF NANGA PARBAT RANGE FROM THE INDUS AT BUNJI.

FIG. 2. VIEW OF THE GREAT HIMALAYA RANGE FROM BURZIL VALLEY.

D N. Wadia, Photos. *G. S. I. Calcutta.*

FIG. 1. THREE RIVER TERRACES AS SEEN FROM THE BUNJI OASIS

FIG. 2. GRANITE VEINS IN EPIDIORITE BLUFFS, PARTABPUL, INDUS

D. N. Wadia, Photos

G. S I. Calcutta

GEOLOGICAL SURVEY OF INDIA.

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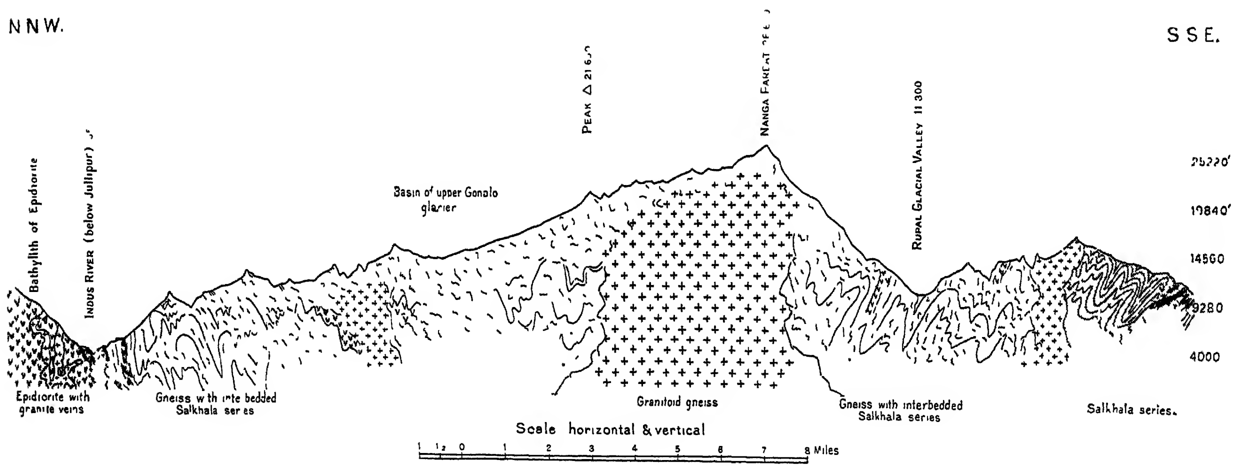


SECTION ACROSS NANGA PARBAT MASSIF FROM THE INDUS RIVER IN CHILAS TO THE RUPAL VALLEY IN ASTOR.

(PARTLY GENERALISED)

G. S I Calcutta.

THINNFELDIA SAHNII, *sp. nov.* nat. size

G S I. Calcutta.

Fig 1

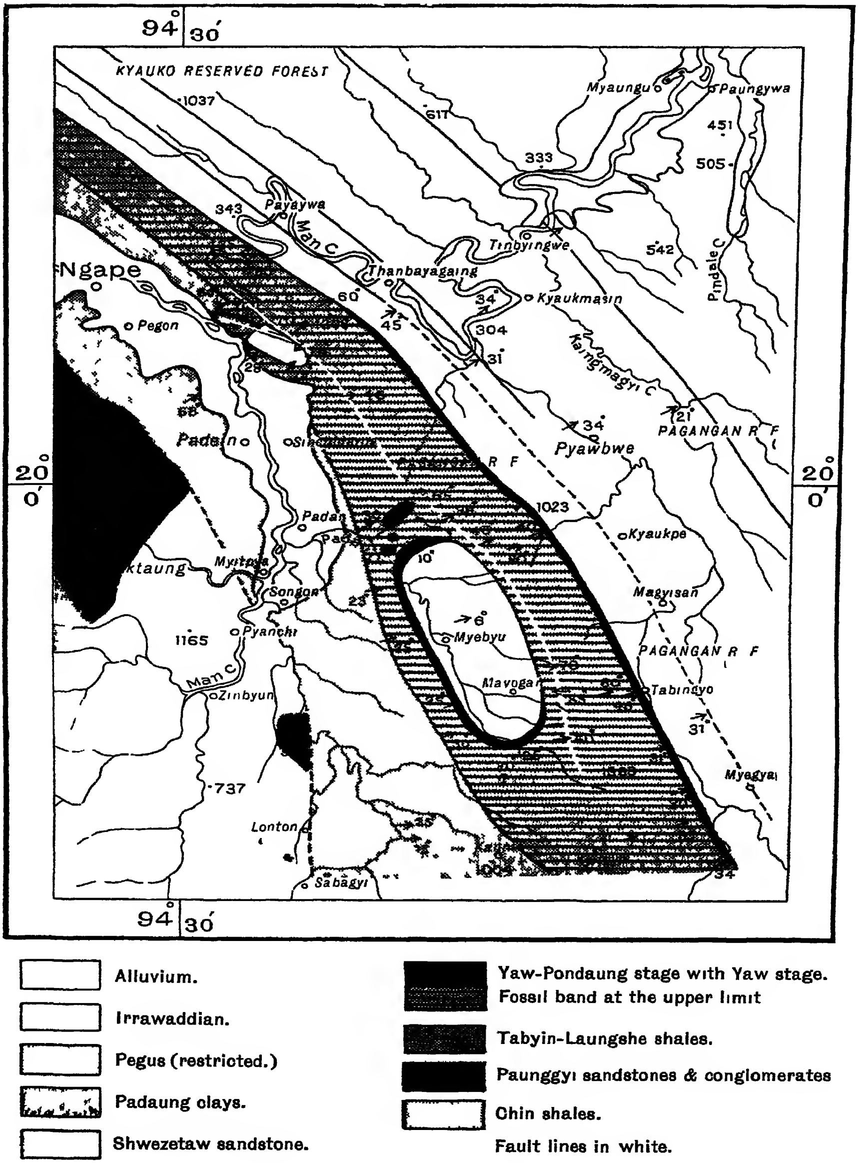
Fig 2

Fig 3

Fig 4

FIG 1 THINNFELDIA SAHNII, *sp. nov* Part of a pinna, nat size
FIG 2 THINNFELDIA SAHNII, *sp nov* Small pinnæ, nat size
FIG 3 THINNFELDIA SAHNII, *sp nov.* Nat size.
FIG 4 THINNFELDIA *sp* Nat size

G S I Calcutta



GEOLOGICAL MAP OF THE
SOUTH END OF THE NWAMATAUNG RANGE,
MINBU DISTRICT, BURMA.

Scale 1 inch = 4 miles.

G. S. I. Calcutta.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1932 [September

THE MINERAL PRODUCTION OF INDIA DURING 1931. BY A. M. HERON, D.SC. (EDIN.), F.G.S., F.R.G.S., F.R.S.E., *Offg. Director, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these *Records* (Vol. XXXII, 1905), although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of collecting the returns become more precise, and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods, and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible; the total error from year to year, however, is characterised by some degree of constancy, and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that the error from this source may be regarded as negligible.

The average value of the Indian rupee during the year 1931 was 1*s*. $5\frac{13}{16}$*d.*; the highest value reached was 1*s*. $6\frac{5}{32}$*d.* and the lowest 1*s*. $5\frac{3}{4}$*d.* The values for 1931 shown in the tables are given on the basis of 1*s*. $5\frac{13}{16}$*d.* to the rupee; for ease of calculation, £1 has been taken to be equivalent to Rs. 13·5 instead of Rs. 13·47.

Table 1 shows the total value of minerals for which returns of production are available for the years 1930 and 1931. The average figure for the quinquennium, 1919-23, was £25,191,1[illegible]3. In the following year, 1924, there was an apparent increase of over £3,500,000; this was, in part, however, due to the higher average value of the rupee during that year. Since 1924, there has been a steady decline, which persisted down to the year 1928, for which the value was £21,888,528. There was an arrest in this decline in 1929, which showed an increase in total value to £22,328,686 or about 2 per cent. over that of 1928. In 1930, however, the decline was resumed and the total value of the production fell by over £2,500,000 to £19,750,233, this continuing in 1931, by over £2,000,000, to £17,739,991. Of each of the thirteen minerals with a

TABLE 1.—*Total value of Minerals for which returns of production are available for the years 1930 and 1931.*

——	1930. (£1= Rs. 13·5).	1931. (£1= Rs. 13·5).	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	6,861,134	6,125,804	..	735,330	—10·7
Petroleum	3,888,727	4,380,389	491,662	..	+12·6
Gold	1,384,090	1,510,885	126,795	..	+11·3
Salt	943,808	1,010,441	66,633	..	+7·1
Lead and lead-ore (*a*)	1,316,051	939,906		406,145	—30·2
Building materials	1,096,035	851,741	..	244,294	—22·3
Manganese-ore (*b*)	1,200,236	726,954	..	473,282	—39·4
Copper-ore and matte	521,003	407,181	..	113,822	—21·8
Silver	571,005	387,351	..	183,654	—32·2
Iron-ore	360,928	308,055	..	52,873	—14·6
Mica (*c*)	562,054	307,316	..	254,738	—45·3
Tin-ore	337,344	259,806	..	77,538	—23·0
Zinc concentrates	190 615	127,669	..	62,946	—33·0
Saltpetre (*c*)	53,445	73,414	19,969	..	+37·4
Tungsten-ore	134,065	65,309	..	68,756	—48·7
Nickel speiss	53,790	49,924	..	3,866	—7·2
Ilmenite	32,993	41,991	8,998	..	+27·3
Jadeite (*c*)	16,187	26,094	9,907	..	+61·2
Clays	28,284	25,615	..	2,669	—9·4
Chromite	64,256	23,335	..	40,921	—63·7
Antimonial lead	26,296	14,781	..	11,515	—43·8
Steatite	15,266	9,001	..	6,265	—41·0
Zircon	4,991	7,972	2,981	..	+59·7
Gypsum	8,408	7,254	..	1,154	—13·7
Refractory materials	15,484	5,108	..	10,376	—67·0
Barytes	3,671	3,200	..	471	—12·8
Ruby, sapphire and spinel.	9,715	3,175	..	6,540	—67·3
Diamonds	5,373	2,569	..	2,804	—52·2
Fuller's earth	2,395	2,542	147	..	+6·1
Magnesite	6,277	2,026	..	4,251	—67·7
Ochre	3,951	1,918	..	2,033	—51·5
Monazite	140	890	750	..	+535·7
Felspar	..	247	247	..	..
Apatite	266	79	..	187	—70·3
Soda	109	31	..	78	—71·6
Serpentine	6	6	..	..	..
Bismuth	24	6	..	18	—75·0
Asbestos	88	5	..	83	—94·3
Columbite	..	4	4	..	..
Bauxite	1,490	..	..	1,490	..
Corundum	162	..	..	162	..
Amber	54	..	..	54	..
Garnet	13	..	..	13	..
Antimony-ore	4	..	..	4	..
TOTAL	19,750,233	17,739,994	758,093	2,768,332	—10·3
			$\underbrace{\qquad\qquad\qquad}_{—2,010,239}$		

(*a*) Excludes antimonial lead. (*b*) Export f.o.b. values. (*c*) Export values.

value of over £100,000 annually, large percentage falls in value are shown by mica (45·3 per cent.), manganese-ore (39·4 per cent.), zinc concentrates (33·0 per cent.), silver (32·2 per cent.), lead and lead-ore (30·2 per cent.), tin-ore (23·0 per cent.), building materials (22·3 per cent.), copper-ore and matte (21·8 per cent.), iron-ore (14·6 per cent.) and coal (10·7 per cent.), while increases are shown by petroleum (12·6 per cent.), gold (11·3 per cent.) and salt (7·1 per cent.). Of less important minerals, saltpetre, jadeite, ilmenite, zircon, monazite, felspar, and fuller's earth had increased output values, and all the rest decreased. An increase or decrease in value does not always correspond to a similar variation in output, and cannot, therefore, be regarded as an infalliable indication of the state of an industry. But in 1931, in all cases except petroleum, an increase or decrease of value accompanied an increase or decrease of production.

It is interesting to compare the changes in the figures of total value recorded in Table 1 with the variations in the average annual value of the leading metals and ores as summarised in Table 2.

The number of mineral concessions granted during the year under review amounted to 351 against 414 in the preceding year. Of these 16 were quarry leases, 270 were prospecting licenses, 64 were mining leases and there was 1 exploring license. This small total compared with the figure (714 mineral concessions) for 1927 is an index of the decreased prospecting and private geological enterprise that accompanies a period of depression.

TABLE 2.—*Average prices in the United Kingdom of Principal Metals and Ores during the years 1930 and 1931.*

	1930. £ per ton.	1931. £ per ton.
Metals—		
Copper, standard	54·67	38·39
Lead, pig, soft foreign	18·08	13·03
Spelter, ordinary	16·75	12·44
Tin, standard	141·95	118·45
Pig-iron, Cleveland No. 3	3·35	2·92
Steel rails	8·50	8·37
Ferro-manganese	11·91	11·25
Gold, fine, per ounce	85·064*sh.*	92·492*sh.*
Silver, standard, per ounce	17·462*d.*	14·665*d.*
Ores—		
Chromite, 48-55 per cent. per ton	£4·158	£4·055
Manganese-ore, first grade, per unit	13·1*d.*	11·7*d.*
Wolfram, per unit	22·75*sh.*	13·59*sh.*

II.—MINERALS OF GROUP I.

Antimony.

The production of antimonial lead obtained as a bye-product in the lead refinery at the Namtu smelter of the Burma Corporation, Limited, decreased from 1,700 tons valued at Rs. 3,54,994 (£26,296) in 1930 to 1,505 tons valued at Rs. 1,99,545 (£14,781) in 1931. This product contains approximately 77 per cent. of lead, 21 per cent. of antimony and from 6 to 8 ozs. of silver to the ton, and is exported to the United States of America for further treatment.

There was no production of antimony-ore in 1931 in the Amherst district, Burma. The output in 1930 amounted to 3 tons valued at Rs. 60 (£4) against 77 tons valued at Rs. 988 (£74) in the previous year.

Chromite.

There was a great decrease in the production of chromite in India from 50,684 tons in 1930 to 19,913 tons in 1931, the production from all sources being about halved, except that from Hassan, which was only a seventh of that of 1930. The total exports from India during the year were, however, again below the production, amounting to 13,243 tons, made up of 7,708 tons from British India and 5,535 tons from Mormugao in Portuguese India, as compared with 22,498 tons and 7,480 tons respectively in the previous year. The decrease in production was accompanied by a fall in the value per ton from Rs. 17·1 in 1930 to Rs. 15·8 in 1931.

Something like half the world's supplies of chromite comes from Southern Rhodesia, which has now become the predominant source of this mineral.

TABLE 3.—*Quantity and value of Chromite produced in India during the years 1930 and 1931.*

	1930.			1931.		
	Quantity.	Value. (£1=Rs. 13·5.)		Quantity.	Value. (£1=Rs. 13·5.)	
	Tons	Rs.	£	Tons	Rs.	£
Baluchistan—						
Zhob . .	25,387	3,77,980	27,998	12,189	1,81,291	13,429
Bihar & Orissa—						
Singhbhum .	5,101	99,222	7,350	2,749	37,269	2,760
Mysore State—						
Hassan .	13,106	2,26,975	16,813	1,888	33,153	2,456
Mysore .	7,090	1,63,279	12,095	3,087	63,313	4,690
TOTAL .	50,684	*8,67,456*	*64,256*	19,913	*3,15,026*	*23,335*

Coal.

There was a decrease during the year of 2,086,613 tons, or about 8·8 per cent., in the output of coal. This decrease was due to Bengal, Bihar and Orissa, Hyderabad and Assam. There were increases in the production of the Central Provinces and Central India, and lesser increases in the Punjab and Rajputana, with a trivial increase in Baluchistan. The decreases in Bihar and Orissa in 1930 and 1931 must be contrasted with the substantial increase recorded in 1929. It is mainly due this year to heavy decreases of 503,652 tons in Bokaro, of 998,821 tons in Jharia, and a trivial decrease to 411 tons in Daltonganj and to *nil* in Hutar, against a small increase in the Rajmahal Hills. All the other fields in this province showed decreases, except Giridih, which increased in production from 613,533 tons to 713,133 tons, the largest actual increase, and Talcher, the production of which increased from 68,973 tons to 142,312 tons, the highest proportionate increase. Bokaro, which now produces 7·6 per cent. of the Indian total, showed a large decrease from 2,160,249 tons to 1,656,597 tons, and Karanpura a small decrease from 482,141 tons to 461,678 tons. Jainti showed a small increase, and Rampur a small decrease, both of much the same amount. The Raniganj field, which lies both in Bengal and Bihar and Orissa, showed a large decrease amounting to 687,978 tons. In Central India there was a decrease in the output from Umaria of 16,824 tons, which was much more than offset by a large increase of 50,519 tons from Sohagpur. In the Central Provinces there was another substantial increase of nearly 10,000 tons in the output from the Pench Valley, as also of over 11,000 tons from Ballarpur, and the initial production of 3,517 tons from Korea in 1930, rose to 31,351 tons in 1931. In Hyderabad, the Singareni field was responsible for a decrease of over 61,000 tons, and Sasti for an increase of nearly 7,000 tons.

In 1929 the statistical position at the end of the year showed a very great improvement in spite of the increase in the total output, stocks in the six provinces of Assam, Baluchistan, Bengal, Bihar and Orissa, the Central Provinces, and the Punjab, for which such figures are available, showing a total reduction of 781,477 tons. In 1930 the smaller increase in production was not accompanied by another improvement in the statistical position, but by a slight worsening, namely an increase of stock amounting to 141,766 tons and in 1931 the position was much less favourable, the increase

amounting to 428,334 tons, as is shown by the following data :—

Year.	Opening stock.	Closing stock.	Reduction during year.
	Tons	Tons	Tons
1927	2,161,806	1,721,288	440,518
1928	1,721,288	1,625,717	95,571
1929	1,625,717	844,240	781,477
1930	844,240	986,006	(*a*) 141,766
1931	986,006	1,414,340	(*a*) 428,334

(*a*) Increase of stocks.

The decreased output of 8·8 per cent. was accompanied by a decrease in the total value of the coal produced in India from Rs. 9,26,25,323 (£6,861,134), in 1930 to Rs. 8,26,98,364 (£6,125,804) in 1931.

There was a decrease in the pit's mouth value per ton of coal for India as a whole, namely from Rs. 3-14-3 to Rs. 3-12-11, a fall of Re. 0-1-4. This was the balance of large rises in four, and large falls in two. minor provinces and smaller falls in the three main producing provinces. In the two great coal provinces, Bihar and Orissa and Bengal, the value fell by Re. 0-1-0 and Re. 0-2-1 respectively, and in the Central Provinces by Re. 0-3-8. On the other hand the price rose in Assam by Rs. 0-7-1 ; in Baluchistan by Rs. 0-6-0 ; in Hyderabad by Re. 0-3-10 ; and in Central India by Re. 0-3-3 ; while in the Punjab it fell by Re. 1-3-10 ; and in Rajputana by Re. 0-10-4.

TABLE 4.—*Provincial production of Coal during the years 1930 and 1931.*

Province.	1930.	1931.	Increase.	Decrease.
	Tons	Tons	Tons	Tons
Assam	359,040	275,021	..	84,019
Baluchistan	15,894	16,554	660	..
Bengal	6,316,528	5,810,184	..	506,344
Bihar and Orissa . . .	15,064,425	13,532,794	..	1,531,631
Central India	193,233	226,928	33,695	..
Central Provinces . . .	955,888	1,004,391	48,503	..
Hyderabad	812,298	757,575	..	54,723
Punjab	50,619	54,840	4,221	..
Rajputana	35,123	38,148	3,025	..
TOTAL .	23,803,048	21,716,435	*90,104*	*2,176,717*

TABLE 5.—*Value of Coal produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Value (£1 = Rs. 13·5.)		Value per ton.	Value (£1 = Rs. 13·5.)		Value per ton.
	Rs.	£	Rs. A. P.	Rs.	£	Rs. A. P.
Assam	38,89,492	288,111	10 13 4	31,02,094	229,785	11 4 5
Baluchistan . . .	1,22,949	9,107	7 11 9	1,34,296	9,948	8 1 9
Bengal	2,49,46,910	1,847,919	3 15 2	2,21,68,189	1,642,088	3 13 1
Bihar and Orissa . .	5,52,33,360	4,091,360	3 10 8	4,87,78,145	3,613,196	3 9 8
Central India . .	7,86,754	58,278	4 1 2	9,70,329	71,876	4 4 5
Central Provinces . .	40,89,680	302,939	4 4 6	40,68,974	301,405	4 0 10
Hyderabad (*a*) . .	30,88,547	228,781	3 12 10	30,61,779	226,798	4 0 8
Punjab	3,07,399	22,770	6 1 2	2,65,067	19,635	4 13 4
Rajputana	1,60,232	11,869	4 9 0	1,49,491	11,073	3 14 8
TOTAL .	9,26,25,323	6,861,134	..	8,26,98,364	6,125,804	..
Average .	..	..	3 14 8	..	..	3 12 11

(*a*) Estimated.

TABLE 6.—*Origin of Indian Coal raised during the years 1930 and 1931.*

—	Average of last five years.	1930.	1931.
	Tons	Tons	Tons
Gondwana coalfields . . .	22,148,992	23,342,372	21,331,872
Tertiary coalfields	420,239	460,676	384,563
Total .	22,569,231	23,803,048	21,716,435

TABLE 7.—*Output of Gondwana Coalfields for the years 1930 and 1931.*

—	1930. Tons.	1930. Per cent. of Indian total.	1931. Tons.	1931. Per cent. of Indian total.
Bengal, Bihar and Orissa—				
Bokaro	2,160,249	9·07	1,656,597	7·63
Daltonganj	1,569	0·01	411	0·00
Giridih	613,533	2·58	713,133	3·28
Hutar	195	0·00	..	..
Jainti	43,580	0·18	50,178	0·23
Jharia	10,753,858	45·18	9,755,037	44·92
Karanpura	482,141	2·02	461,078	2·13
Rajmahal Hills	445	0·00	1,699	0·01
Rampur (Raigarh-Hingir)	37,719	0·16	31,220	0·14
Raniganj	7,218,691	30·33	6,530,713	30·07
Talcher	68,973	0·29	142,312	0·66
Central India—				
Sohagpur	93,088	0·39	143,607	0·66
Umaria	100,145	0·42	83,321	0·38
Central Provinces—				
Ballarpur	211,980	0·89	223,025	1·03
Korea	3,517	0·01	31,351	0·14
Pench Valley	740,391	3·11	750,015	3·45
Hyderabad—				
Sasti	46,808	0·20	53,417	0·25
Singareni	765,490	3·22	704,158	3·24
Total	23,342,372	*98·06*	21,331,872	*98·22*

TABLE 8.—*Output of Tertiary Coalfields for the years 1930 and 1931.*

—	1930. Tons.	1930. Per cent. of Indian total.	1931. Tons.	1931. Per cent. of Indian total.
Assam—				
Khasi and Jaintia Hills	1,005		743	
Makum	307,414	1·51	239,315	1·27
Naga Hills	50,621		34,963	
Baluchistan—				
Khost	3,355	0·07	3,821	0·08
Sor Range, Mach, Kalat	12,539		12,733	
Punjab—				
Jhelum	26,904		27,386	
Mianwali	20,011	0·21	22,831	0·25
Shahpur	3,704		4,623	
Rajputana—				
Bikaner	35,123	0·15	38,148	0·18
Total	460,676	*1·94*	384,563	*1·78*

The export statistics for coal during 1931 show a decrease of about 20,000 tons, which however is only about a thirteenth of the previous year's fall of over 261,000 tons, the total exports of coal and coke falling from 161,188 tons to 141,219 tons, 2,286 tons of the latter being coke (*see* Table 9). Exports to Hongkong increased to 89,127 tons as against 61,885 tons in the previous year. As before, the major portion of the exports went to Ceylon, which took only 443 tons less than during the previous year. Exports to the Straits Settlements (including Labuan) increased by nearly 4,000 tons and to the Philippine Islands and Guam showed a substantial decrease of about 24,000 tons. The United Kingdom took 10,785 tons against 27,587 tons in the previous year and other countries absorbed about 11,000 tons less. The export of coke increased by 1,004 tons.

TABLE 9.—*Exports to foreign ports of Indian Coal and Coke during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs.	£	Tons	Rs.	£
To—						
Ceylon . . .	282,127	34,20,204	253,348	281,684	34,20,682	253,384
Hongkong . . .	61,885	6,00,908	44,512	89,127	8,16,628	60,491
Philippine Islands and Guam.	45,558	3,05,574	29,302	21,770	1,80,670	13,381
Straits Settlements (including Labuan).	25,631	2,74,272	20,316	29,322	3,08,092	22,858
United Kingdom .	27,587	2,92,519	21,668	10,785	94,062	6,967
Other countries . .	17,115	1,79,552	13,300	6,275	66,215	4,907
TOTAL .	159,906	51,63,029	382,446	438,963	48,87,268	362,021
Coke	1,282	24,888	1,844	2,286	45,137	3,366
Total of coal and coke .	461,188	51,87,917	384,290	441,249	49,32,725	365,387

This figure of exports, although the lowest for the 6 years (1926 to 1931) during which the Indian Coal Grading Board has been established, is nevertheless double those of the five years preceding the establishment of this Board; last year's heavy fall must be regarded as a reflection of the bad trading conditions. The following

table gives the amounts of different grades of coal exported during 1930 and 1931 under the above scheme (including sea-borne coal for railways in Southern India, for which no grade shipment certificates were issued by the Coal Grading Board) and shows an increase of 92,935 tons in the present year, the difference between the total amounts so exported (2,168,554 tons in 1931) and the total exports of Indian coal to foreign ports given in Table 9 (441,249 tons in 1931) being the amount of coal exported to Indian ports.

TABLE 10.—*Exports of Coal under Grading Board Certificates during the years 1930 and 1931.*

——	1930.	1931.
	Tons.	Tons.
Selected grade	1,807,669	1,980,021
Grade I	263,196	185,067
Grade II	..	2,271
Grade III	919	..
Mixed grade	3,335	1,195
Under reference	500	..
Total	2,075,619	2,168,554

Imports of coal and coke showed during 1931 a much greater fall, as they decreased from 217,029 tons in 1930 to 88,035 tons in 1931; 11,949 tons of the latter consisted of coke (*see* Table 11). This fall is due to a decrease of some 138,000 tons from South and Portuguese East Africa, all other countries showing an increase, the principal being a rise of 12,000 tons from the United Kingdom. The total imports are now less than a fifth of those of the pre-war quinquennium and Table 12, comparing pre-war imports and exports with the figures from 1926 to 1931, shows that the depression in the Indian coal industry, which continued till nearly the end of 1928, can no longer be looked upon as attributable to the competitive effect of foreign imported coal. The average surplus of exports over imports during the years 1926 to 1931 was, in fact, greater than the surplus during the pre-war quinquennium.

TABLE 11.—*Imports of Coal and Coke, during the years 1930 and 1931.*

—	1930			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
Australia	1,100	23,800	1,763	3,400	74,590	5,525
Portuguese East Africa .	5,061	96,154	7,122	..	..	..
United Kingdom . .	15,802	3,34,846	24,766	27,920	6,27,540	46,484
Union of South Africa .	172,097	30,85,718	228,572	39,441	6,74,025	49,928
Other countries . .	4,087	62,670	4,643	5,325	84,422	6,253
TOTAL .	198,327	36,02,697	266,866	76,086	14,60,577	108,190
Coke	18,702	5,34,290	39,577	11,049	3,23,212	23,942
Total of coal and coke .	217,029	*41,36,987*	*306,443*	88,035	*17,83,789*	*132,132*

TABLE 12.—*Excess of exports over imports of Coal.*

—	Exports.	Imports.	Excess of exports over imports.
	Tons.	Tons.	Tons.
Average for 1909-13	814,475	466,162	348,313
1926	617,563	193,908	423,655
1927	576,167	243,603	332,564
1928	626,343	210,186	416,157
1929	726,610	218,560	508,050
1930	461,188	217,029	244,159
1931	441,249	88,035	353,214

The average number of persons employed in the coalfields during the year showed a considerable decrease (6·1 per cent.) accompanying the greater decrease in production (8·8 per cent.). The average output per person employed, therefore, showed a decrease to 125·4 tons in contrast with the advances up to last year, which have been 110·5 tons for 1925, rising to 113·1 tons for 1926, 122·3 tons for 1927, 125·5 tons for 1928, 130·4 tons for 1929, and 129·1 tons for

1930. Except for the last three years, however, the figure for the year under review is higher than any previously recorded; these higher figures are due, partly to an increased use of mechanical coal-cutters, and partly to concentration of work. During the past few years a large number of collieries have been shut down and the labour absorbed in the remainder; this concentration permits of a proportional reduction of the supervising staff, resulting in a larger tonnage per head. There was a decrease in the number of deaths by accident from 227 in 1930 to 196; the latter figure is much better than the annual average for the quinquennium 1919-1923, which was 274, and also below the annual average for the quinquennium 1924-1928, which was 218. In addition, it relates to a production which is over a million tons in excess of the average for 1919-1923 and nearly half a million tons in excess of the average for 1924-1928. The death rate was 1·1 per thousand persons employed in 1931, a little less than the figure for the previous year (1·2); the average figure for the period 1919-1923 was 1·36, and for the period 1924-1928 was 1·16.

TABLE 13.—*Average number of persons employed daily in the Indian Coalfields during the years 1930 and 1931.*

——	1930.	1931.	Output per person employed in tons.	Number of deaths by accident.	Death rate per 1,000 persons employed.
Assam	4,401	3,533	77·8	4	1·1
Baluchistan	281	261	63·4	..	..
Bengal	46,592	44,642	130·2	55	1·2
Bihar and Orissa	110,363	102,115	132·5	109	1·1
Central India	1,915	1,851	122·6	2	1·1
Central Provinces	7,972	9,138	109·9	15	1·6
Hyderabad	11,751	10,501	72·1	9	0·9
Punjab	964	985	55·7	2	2·0
Rajputana	131	149	256·0	..	..
Total	184,370	173,175	..	196	..
Average	..	..	*125·4*	..	*1·1*

Cobalt (*see* Nickel).

Copper.

The progress of work at the Mosaboni Mine of the Indian Copper Corporation, Ltd., in the Singhbhum district, and on the milling and smelting plant at Maubhandar, near Ghatsila, Bengal Nagpur Railway, has been noticed in previous reviews. Operations commenced on a revenue basis on January 1st, 1929. During that year the ore produced amounted to 76,831 long tons valued at Rs. 14,58,716 (£108,862). Of this 75,171 short tons were treated in the mill and smelter, with the production of 1,635 long tons of refined copper ingots and slabs. The copper was sold entirely in India at an average price of Rs. 1,200 per long ton. In 1930 the output increased to 123,749 long tons of copper-ore valued at Rs. 24,35,571 (£180,413). Of this 131,162 short tons were treated in the mill and smelter and 1,625 short tons sent direct to the smelter with the production of 2,9,4 long tons of refined copper of which 2,157 tons were sold in the Indian market and 540 tons were consumed in the new rolling mill, which was completed in July 1930, with the production of 712 tons of yellow metal (brass) sheet, which found a ready market in Calcutta.

Operations continued uninterruptedly during the year 1931 at the Mosaboni Mine and at the works site at Moubhandar. The mine output increased to 153,636 long tons of copper ore valued at Rs. 22,71,940 (£168.292). 161,563 short tons of ore were treated in the mill and production of refined copper amounted to 4,069 long tons. 2,462 tons were consumed in the rolling mill and 1,668 tons were sold in the Indian market at an average price of Rs. 673 per ton. Operations in the rolling mill resulted in the production of 3,637 tons of yellow metal, of which 3,613 were sold in India at an average price of Rs. 719 per ton.

The total ore reserves at the close of the year 1931 amounted to 691,942 short tons with an average assay value of 3·249 per cent. of copper.

There was a considerable decrease in the production of copper-matte at the Namtu smelting plant of the Burma Corporation Limited, from 17,146 tons in 1930, valued at Rs. 45,97,974 (£340,590), and averaging 41·91 per cent. of copper, 28·01 per cent. of lead, and 69·85 ozs. of silver to the ton, to 13,437 tons valued at Rs. 32,25,003 (£238,889) in 1931, averaging 43·54 per cent. of copper,

27·77 per cent. of lead, and 81·97 ozs. of silver to the ton. The decrease in total value was due, of course, to the heavy falls in the prices of metals during the year.

Diamonds.

The production of diamonds in Central India fell from 1,321·2 carats valued at Rs. 72,533 (£5,373) in 1930, to 639 carats valued at Rs. 34,683 (£2,569) in 1931. Of this latter production 571·8 carats were produced in Panna State and the remainder in Charkhari and Ajaigarh.

Gold.

The gradual secular decline in the total Indian gold production was slightly arrested, the increase being from 329,232·3 ozs. valued at Rs. 1,86,85,211 (£1,384,090) in 1930 to 330,488·8 ozs. valued at Rs. 2,08,01,943 (£1,540,885) in 1931, almost the whole of this increase being due to the Kolar goldfield. The small production in Singhbhum ceased, that from Burma was almost halved, and from the Punjab and United Provinces doubled, but these figures are quite insignificant compared with Kolar. The considerable increase in the value of the production was due in part to the appreciation in price of gold, against sterling or rupees, during the last quarter of the year.

Of the five mines producing gold on the Kolar goldfield, the two deepest, namely Champion Reef and Ooregum, reached vertical depths of 7,093 feet and 7,053 feet, respectively, below field datum, on the 31st of December, 1931. A gratifying feature of the developments in depth is the continuity of the reef and the opening up of bodies of payable ore. The dip of the reef is almost vertical in the lower levels. The ore is not refractory and yields its gold to a simple combination of amalgamation and cyaniding; 'all-sliming' is gradually becoming general and battery plate amalgamation is being eliminated. The rock temperature at the 74th level, Champion Reef Mine, was 125·7°F. Owing to the great depths of these mines and the high rock temperatures, the problem of ventilation has been an extremely difficult one. It has been solved to some extent by sinking deep smooth-lined vertical shafts and by an extensive use of large electrically-driven fans to help the main air currents. A large volume of air is constantly kept in circulation by these fans, installed in convenient places in the main airways. The brick and

concrete-lined shafts and winzes, which are coming more and more into vogue in deep level mining in this field, considerably assist the free movement and increase the circulation of the air by reducing friction. The shafts themselves are cleaner and less liable to damage by rock-bursts. The latter, even with the improved and more rigid forms of support adopted in place of the usual timbering and waste-rock filling, are still a source of anxiety and at times cause considerable damage to underground workings.

The average number of persons employed on the Kolar gold-field during 1931 was 18,388.

TABLE 14.—*Quantity and value of Gold produced in India during the years 1930 and 1931.*

—	1930.			1931.			Labour.
	Quantity.	Value (£1 Rs. 13·5).		Quantity.	Value (£1 — Rs. 13·5).		
	Ozs.	Rs.	£	Ozs.	Rs.	£	
Bihar and Orissa—							
Singhbhum .	30·0	1,500	111	..	..	..	..
Burma—							
Katha . .	44·8	3,225	230	18·8	1,005	75	1
Upper Chindwin.	14·8	1,225	91	18·0	960	71	..
Mysore . .	329,133·9	1,86,78,794	1,383,015	330,437·5	2,07,99,131	1,540,676	18,388
Punjab . .	6·9	887	27	10·0	583	43	48
United Provinces	1·9	100	7	4·5	264	20	10
Total .	329,232·3	*1,86,85,711*	*1,384,090*	330,488·8	*2,08,01,943*	*1,540,885*	*18,447*

Ilmenite.

There was an increase in the production of ilmenite in the Travancore State from 28,776 tons valued at £32,993 in 1930 to 36,166 tons valued at £41,991 in 1931. This mineral is collected with the monazite sands and, up to a few years ago, was looked upon as a bye-product of the monazite industry. Recently, the increasing demand for the titania in the ilmenite appeared to have caused a resuscitation of the monazite industry, which had been adversely affected by the increased use of electricity for lighting purposes; but in 1930 the increase in the output of ilmenite was accompanied by a heavy fall in that of monazite.

Iron.

For some years up to and including 1929 the production of iron-ore in India had been steadily increasing; India is now, in fact, the second largest producer in the British Empire, and yields place only to the United Kingdom. Her output is of course still completely dwarfed by the production in the United States (over 58 million tons in 1930) and France (nearly 49 million tons in 1930); but her reserves of ore are not much less than three-quarters of the estimated total in the United States, and there is every hope that India will eventually take a much more important place among the world's producers of iron-ore. In 1930, however, the prevailing depression was reflected in a decrease in the Indian output over the previous year of 23·8 per cent. amounting to 578,930 tons, followed by a further fall of 224,742 tons (12·1 per cent.) in 1931. The figures shown against the Keonjhar and Mayurbhanj States in Table 15 represent the production by the United Steel Corporation of Asia, Ltd., and the Tata Iron and Steel Co., Ltd., respectively. Of the total production of 588,290 tons shown against Singhbhum, 415,929 tons were produced by the Tata Iron and Steel Co., Ltd., from their Noamundi mine, 4,911 tons by the Bengal Iron Co. Ltd., from Ajita and Macllellan mines, and 153,306 tons by the Indian Iron and Steel Co. Ltd., from their mines at Gua; the remaining 14,144 tons were produced by another firm. The output of iron-ore in Burma is by the Burma Corporation, Limited and is used as a flux in lead smelting.

TABLE 15.—*Quantity and value of Iron-ore produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1=Rs. 13·5).		Quantity.	Value (£1=Rs. 13·5).	
	Tons	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Keonjhar	21,909	31,136	2,306	109,841	1,09,841	8,136
Mayurbhanj	650,392	19,78,176	146,532	901,246	27,03,738	200,277
Puri	..	..	..	9	12	1
Sambalpur	6	45	3	..	..	..
Singhbhum	1,090,435	26,20,243	191,092	588,290	12,65,825	93,728
Burma—						
Northern Shan States	33,458	(a) 1,33,832	9,913	1,886	(a)7,544	559
Central Provinces	925	2,775	206	763	2,289	170
Madras—						
East Godavari	..	..	..	4,329	2,597	192
Mysore State	31,500	1,06,320	7,876	18,519	67,391	4,992
Total	1,849,625	*48,72,527*	*360,928*	1,624,883	*41,58,737*	*308,055*

(a) Estimated.

In contrast with the preceding year there was a rise in the total output of iron and steel by the Tata Iron and Steel Co. at Jamshedpur. The production of pig-iron rose from 695,923 tons in 1930, to 799,545 tons in 1931, with increases in the production of steel (including steel rails) from 427,035 tons in 1930 to 439,134 tons in 1931, and of ferromanganese from 4,576 tons in 1930 to 14,366 tons in 1931. The production of pig-iron by the Bengal Iron Co. fell from 103,929 tons in 1930 to nothing in 1931; their output of products made from their pig-iron in 1931 amounted to 28,211 tons of sleepers and chairs, and 32,760 tons of pipes and other castings, against 3,153 tons and 34,833 tons, respectively, in 1930. The Indian Iron & Steel Co. decreased their production of pig-iron from 354,772 tons in 1930 to 243,214 tons in 1931. The output of pig-iron by the Mysore Iron Works fell from 20,668 tons in 1930 to 15,577 tons in 1931. The total production of pig-iron in India fell from 1,175,292 tons in 1930 to 1,058,336 tons in 1931.

The total number of indigenous furnaces that were at work in the Central Provinces during the year 1931 for the purpose of smelting iron-ore was 106 against 124 in the previous year; 53 furnaces were operating in the Bilaspur district, 49 in Mandla, 3 in Raipur, 1 in Saugor, with none in Drug or Jubbulpore.

With the decrease in the production of pig-iron in India recorded above, the quantity exported fell heavily from 502,629 tons in 1930 to 318,694 tons in 1931. Table 16 shows that Japan is still the principal consumer of Indian pig-iron, and the proportion rose from 40 per cent. of the total exports in 1930 to 49 per cent. in 1931, though the actual amount fell by 22 per cent. Exports to all other countries fell by about half, except to Germany, to which a rise of about 40 per cent. took place. There was a fall in the export value per ton of pig-iron from Rs. 41·2 (£3·05) in 1930 to Rs. 35·1 (£2·6) in 1931.

The Steel Industry (Protection) Act, 1924, Act No. XIV of 1924, authorised, to companies employing Indians, bounties upon rails and fishplates wholly manufactured in British India from material wholly or mainly produced from Indian iron-ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons, a substantial portion of the component parts of which had been manufactured in British India. This Act was repealed by the Act No. III of 1927 and the payment of bounties consequently ceased on the 31st March 1927; the

industry is, however, protected to a certain extent by varying tariffs on different classes of imported steel.

TABLE 16.—*Exports of Pig-iron from India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1=Rs. 13·5).		Quantity.	Value (£1=Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
Germany	10,307	4,27,138	31,640	14,552	5,09,371	37,731
Japan	201,997	85,69,869	634,805	157,116	55,82,387	409,803
United Kingdom	116,762	17,75,685	353,754	51,600	17,92,440	132,773
United States of America.	108,024	43,32,192	320,903	60,121	21,15,522	156,705
Other countries	64,639	25 94,174	192,161	35,305	12,48,297	92,096
TOTAL	502,829	*2,06,99,058*	*1,533,263*	318,694	*1,11,92,967*	*899,108*

Jadeite.

There was a substantial increase in the output of jadeite, which rose from 1,499 cwts. valued at Rs. 3,66,487 (£27,147) in 1930 to 2,765 cwts., valued at Rs. 7,72,860 (£57.249), in 1931. The output figures are liable to be incomplete, and a more correct idea of the extent of the Burmese jadeite industry, especially of values, is sometimes obtainable from the export figures. Exports by sea rose from 1,475 cwts. valued at Rs. 2.18,522 (£16,187) in 1930-31 to 2,500 cwts. valued at Rs. 3,52.261 (£26,091) in 1931-32. These shipments were entirely from Burma. Exports from Burma by land during the year amounted to 51 cwts. only.

Lead.

The production of lead-ore at the Burma Corporation's Bawdwin mines in Burma decreased from 529,814 tons in 1930 to 397,679 tons in 1931, and the total amount of metal extracted decreased from 79,730 tons (including 1,700 tons of antimonial lead) valued at Rs. 1.85,04,616 (£1,370,712) to 74,785 tons of lead (including 1,505 tons antimonial lead) valued at Rs. 1,28,88,270 (£954,687) in 1931. The quantity of silver extracted from the Bawdwin ores fell from 7,054,206 ozs. valued at Rs. 76,87,674 (£569,457) in 1930 to 5,900,400 ozs. valued at Rs. 51,97,367 (£384,990) in 1931. The value of the lead per ton fell from Rs. 232·1 (£17·2) in 1930 to Rs. 172·3 (£12·8) whilst the value of the silver fell from Rs. 1-1-5 (19·37*d.*) in 1930 to Rs. 0-14-1 (15·64*d.*) in the year under review. The ore reserves in the Bawdwin mine, as calculated at the end of June,

Table 17.—*Production of Lead-ore, Lead and Silver in India during the years 1930 and 1931.*

	1930.					1931.				
	Quantity.	Value (£1 = Rs. 13·5).				Quantity.	Value (£1 = Rs. 13·5).			
	Lead-ore.	Lead-ore and lead.		Silver.		Lead-ore.	Lead-ore and lead.		Silver.	
	Tons.	Rs.	£	Rs.	£	Tons.	Rs.	£	Rs.	£
Burma—										
Northern Shan States . . .	529,814	(*a*)1,85,04,616	1,370,712	(*b*)76,87,674	569,457	397,679	(*c*)1,28,88,270	954,687	(*d*)51,97,367	384,990
Southern Shan States . . .	305	21,425	1,587	..	..	..	..	..	..	..
Rajputana—										
Jaipur	5	650	48	..	..	..	..	..	..	..
Total .	530,124	*1,85,26,691*	*1,372,347*	*76,87,674*	*569,457*	397,679	*1,28,88,270*	*954,687*	*51,97,367*	*384,990*

(*a*) Value of 78,030 tons of lead (Rs. 1,81,49,622) and 1,700 tons of antimonial lead (Rs. 3,54,994) extracted.
(*b*) Value of 7,054,206 ozs. of silver extracted.
(*c*) Value of 78,280 tons of lead (Rs. 1,26,88,725) and 1,605 tons of antimonial lead (Rs. 1,99,545) extracted.
(*d*) Value of 5,990,499 ozs. of silver extracted.

1931, totalled 4,233,120 tons, against 4,265,665 tons at the end of June, 1930, with an average composition of 25·5 per cent. of lead, 15·3 per cent. of zinc, 0·76 per cent. of copper, and 20·1 ozs. of silver per ton of lead. Included in this reserve are 111,000 tons of copper-ore, the average composition of which is 5·0 per cent. copper, 14·0 per cent. lead, 6·0 per cent. zinc and 16·0 ozs. of silver per ton of lead. The most important features of development work during the year were the intersection of the Meingtha lode, 40 feet wide, on No. 4 level and its location at the horizon of No. 1 level. Developments in it resulted in 277,000 tons of ore being added to reserve, and in the Shan lode, in the addition of 140,000 tons reserve ore.

Magnesite.

The output of magnesite from Salem district, Madras, and Mysore State, fell to about a third of its 1930 amount. The total decrease in output in India amounted to 11,190 tons, accompanied by a decrease in value of Rs. 57,391 (£4,251).

TABLE 18.—*Quantity and value of Magnesite produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1=Rs. 13·5).		Quantity.	Value (£1=Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
Madras—						
Salem . .	15,563	67,978	5,035	4,978	21,540	1,596
Mysore State .	960	16,761	1,242	355	5,808	430
TOTAL .	16,523	*84,739*	*6,277*	5,333	*27,348*	*2,026*

Manganese.

Before the year 1926, the record production of manganese-ore in India took place in the year 1907, when 902,291 tons were raised. In 1926, the output rose to 1,014,928 tons, valued at £2,463,491 f.o.b. Indian ports; the rise in output was, however, accompanied by a decrease in value. In 1927 the production rose to the highest figure yet recorded, 1,129,353 tons, accompanied by a rise in value to the peak figure of £2,703,068 f.o.b. Indian ports. During the year 1928, the upward tendency was not maintained, the output falling to 978,449 tons valued at £2,198,895 f.o.b. Indian ports. In 1929, the output rose again slightly to 994,279 tons, but the

value fell heavily to £1,571,030, and in 1930 the output fell substantially to 829,916 tons with a heavy fall in value to £1,200,236. In the year under review a still more serious fall took place, to 537,814 tons with a value of £726,951. The decrease, totalling 292,102 tons, was distributed over all producing districts, except Sandur and Keonjhar States, which showed a joint increase of some 6,000 tons, with a trifling increase from Chitaldrug. Production ceased from Bonai, Chhota Udepur, North Kanara, Cuddapah and Tumkur.

In 1924, first-grade ore, c.i.f. United Kingdom ports, fetched an average price of 22·9*d.* per unit, in 1925 this price fell to 21·5*d.*, in 1926 to 18·1*d.*, in 1927 to 18·1*d.*, in 1928 to 17·0*d.*, with a heavy fall in 1929 to an average price of 14·0*d.* per unit. In 1930 the price fell to 13·1*d.* per unit, that is to the post-war lower governing price of manganese,[1] with an index figure of cost of supplies and services of 1·45, and in 1931 to 11·8*d.* per unit. This continued fall in the price of manganese-ore from 1924 to 1931 is to be correlated with the fact that from 1924 to 1927 the rate of increase of the world's production of manganese-ore was much greater than the rate of increase in the world's production of pig-iron and steel. And although there was a fall in the world's output of manganese-ore in 1928, there was a very large increase in 1929, greater than was justified by the increased production of iron and steel in that year, and it is evident that the world's available supplies of manganese-ore are now much in excess of requirements. Russia, by non-economic methods of exploitation and finance, is able to place large quantities of ore on the market at a price well below both the critical figure of 13·1*d.* referred to above and also below any revised figure allowing for the fall in index figures. At the end of the year the price of Russian ore was reduced to 9*d.* (sterling) c.i.f. per unit, a figure with which India cannot compete, and the Indian trade has suffered severely. The large deposits of high-grade manganese-ore discovered near Postmasburg in South Africa are also being developed, and it may be anticipated that eventually South Africa will secure a substantial portion of the world's market. It is not surprising, therefore, that in spite of the apparent prosperity of the Indian manganese industry in 1929 and 1930 as judged from figures of production and export, yet by 1930 the industry as a whole had arrived at a stage of relative depression, causing

[1] See *Rec. Geol. Surv. Ind.*, Vol. LXIV, p. 192 (1930).

many operators to cease work, and conditions were still worse in 1931.

The present chief sources of production of manganese-ore are now India, Russia, the Gold Coast, South Africa, and Brazil.

There is a steady consumption of manganese-ore at the works of the three principal Indian iron and steel companies, not only for use in the steel furnaces of the Tata Iron and Steel Company, and for the manufacture of ferro-manganese, but also for addition to the blast-furnace charge in the manufacture of pig-iron. The consumption of manganese ore by the Indian iron and steel industry in the year under review amounted to 53,037 tons, against 46,099 tons in 1930.

TABLE 19.—*Quantity and value of Manganese-ore produced in India during the years 1930 and 1931.*

—	1930.		1931.	
	Quantity.	Value f.o.b. at Indian ports.	Quantity.	Value f.o.b. at Indian ports.
	Tons.	£	Tons.	£
Bihar and Orissa—				
Bonai State . . .	165	171	..	..
Keonjhar State . .	37,356	38,751	39,665	40,987
Singhbhum . . .	11,203	17,644	7,938	12,370
Bombay—				
Belgaum	2,356	3,711	474	739
Chhota Udepur . . .	3,984	5,080	..	..
North Kanara . . .	4,500	7,087	..	..
Panch Mahals . . .	36,542	57,553	31,184	48,595
Central Provinces—				
Balaghat	220,018	370,364	119,466	198,115
Bhandara	150,133	252,724	82,999	137,640
Chhindwara	27,170	45,735	16,404	27,203
Nagpur	155,023	260,955	83,475	138,429
Madras—				
Bellary	3,470	2,646	44	34
Cuddapah	50	38	..	..
Sandur State . . .	145,961	111,295	149,833	117,369
Vizagapatam . . .	13,213	11,286	5,389	4,670
Mysore—				
Chitaldrug . . .	241	195	425	351
Shimoga	18,283	14,779	548	452
Tumkur	278	222	..	..
TOTAL .	*829,946*	*1,200,236*	*537,844*	*726,954*

Exports, including the quantities exported from Mormugao in Portuguese India, fell from 773,026 tons in 1930 to 417,957 tons in 1931. Table 21 shows the distribution of manganese-ore exported from British Indian ports (excluding Mormugao) during 1930 and 1931, from which it will be seen that the United Kingdom with a fall in imports of over 100,000 tons, has again given place as chief importer of Indian manganese-ore to France, which, however, showed a decrease of about 119,000 tons. Belgium again showed a large decrease of some 56,700 tons, and the Netherlands of 8,000 tons, whilst the imports of Italy fell to *nil*. Germany showed a decrease of some 20,000 tons and the United States of some 15,000 tons. Other countries decreased their takings by about 33,000 tons.

TABLE 20.- *Exports of Manganese-ore during 1930 and 1931 according to ports of shipment.*

Port.	1930.	1931.
	Tons.	Tons.
Bombay	297,738	88,681
Calcutta	300,211	153,535
Madras	4,500	4,331
Mormugao (Portuguese India)	170,577	171,410
TOTAL	773,026	417,957

TABLE 21.-- *Exports of Manganese-ore from British Indian ports during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom	161,895	49,71,761	368,279	61,313	17,02,630	132,788
Germany	24,380	7,78,745	57,685	4,240	1,28,779	9,539
Netherlands	11,500	3,84,000	28,444	3,500	1,29,375	9,583
Belgium	98,205	29,34,938	217,403	41,500	12,77,475	94,628
France	208,867	54,11,728	400,869	90,009	20,43,310	151,356
Italy	620	15,600	1,155	..	..	..
United States of America	54,000	15,94,500	118,111	38,970	11,70,800	86,726
Other countries	30,982	10,81,769	80,131	7,015	1,77,299	13,133
TOTAL	602,449	*1,71,73,041*	*1,272,077*	246,547	*67,19,677*	*497,753*

Mica.

There was a large fall in the declared production of mica from 52,727 cwts. valued at Rs. 26,68,986 (£197,703) in 1930 to 38,963 cwts. valued at Rs. 20,37,634 (£150,935) in 1931. Last year's was the highest production yet recorded, with the exception of those of 1918 (54,710 cwts.) and 1929 (53,231 cwts.). As has been frequently pointed out, the output figures are incomplete, and a more accurate idea of the size of the industry is to be obtained from the export figures. In the years 1928 and 1929 the quantity exported was more than double the reported production, whilst in both the years 1926 and 1927 also the export figure was approximately double the reported production figure. In 1930 the recorded exports were, however, only some 57 per cent. in excess of the reported production, and in 1931 only 36 per cent, in excess. This may mean that the Act referred to in the third paragraph is now beginning to produce a definite effect. This will be conclusively proved only by statistics over a period of years.

The United States of America and the United Kingdom, which are the principal importers of Indian mica, absorbed respectively 28·9 per cent. and 46·4 per cent. during 1930, and 23·4 per cent. and 45·2 per cent. during 1931. Germany took 9·4 per cent. and 7·2 per cent., respectively, of the total quantities exported during the years 1930 and 1931. The average value of the exported mica decreased from Rs. 91·5 (£6·8) per cwt. in 1930 to Rs. 78·3 (£5·8) per cwt. in 1931. The exports fell from 82,909 cwts. valued at Rs. 75,87,731 (£562,054) in 1930, to 52,966 cwts. valued at Rs. 41,48,768 (£307,316) in 1931. This is the lowest total value recorded since 1915-16, when the value of the mica exports was £208,496.

The difference between exports and production is generally attributed to theft from the mines. If this be the only explanation we must assume that during the three years prior to 1930 there has been as much mica stolen as won by honest means. Early in 1928 a bill was introduced into the Legislative Council of Bihar and Orissa, the purpose of which was an attempt to reduce the losses on this account by licensing miners and dealers; the bill was, however, rejected. In March, 1930, however, a similar bill to regulate the possession and transport of, and trading in, mica was passed, and from the figures presented since 1930, as analysed above, it appears that this bill may already have produced a good effect.

TABLE 22.—*Quantity and value of Mica produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5)		Quantity.	Value (£1 = Rs. 13·5).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bihar and Orissa—						
Gaya	9,150	3,57,731	26,199	6,051	3,21,283	23,799
Hazaribagh . . .	31,260	16,19,620	119,972	25,577	13,43,215	99,497
Monghyr	477	14,853	1,100	92	5,222	387
Madras—						
Nellore	11,177	6,40,014	47,409	6,893	3,41,094	25,266
Nilgiris	171	13,747	1,018	65	10,936	810
Rajputana—						
Ajmer-Merwara . .	284	14,718	1,090	185	10,884	806
Jaipur State . . .	73	5,000	370	100	5,000	370
Shahpura State . .	135	3,303	245	..	..	..
TOTAL .	**52,727**	*26,68,986*	*197,703*	**38,963**	*20,37,634*	*150,935*

TABLE 23.—*Quantity and value of Mica exported from India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
United Kingdom .	38,478	35,92,623	266,120	22,891	24,05,167	178,160
Germany . . .	7,768	4,86,562	36,042	3,831	2,00,931	14,884
France . . .	5,050	3,03,179	22,458	4,810	97,992	7,259
United States of America.	23,082	25,26,164	187,123	12,378	7,18,550	53,226
Other countries . .	7,611	6,79,203	50,311	9,056	7,26,128	53,787
TOTAL .	**82,989**	*75,87,731*	*562,054*	**52,966**	*41,48,768*	*307,316*

Monazite.

The monazite industry of Travancore, which was moribund in the year 1925, when the reported production was 1 cwt. only, showed signs of revival in 1926, the output amounting to 64·2 tons valued at £947. The production rose to 280 tons valued at £3,810 in 1927, fell to 103·4 tons valued at £1,242 in 1928, and rose again to 180 tons valued at £1,800 in 1929. In 1930 the production fell again heavily to 14 tons valued at £140 but in 1931 rose again to 89·6 tons, valued at £890. The decline of the industry from the high figure of 1919 to 1921 is of course due to the supplanting of incandescent mantles for gas lighting by electricity. It is hoped that ilmenite, collected with the monazite and hitherto regarded as a bye-product, may be the means of reviving the industry; titania forms a valuable white paint superior to white lead in being non-poisonous and in possessing twice the covering power.

Nickel.

As a bye-product in the smelting operations of the Burma Corporation, Limited, at Namtu, in the Northern Shan States, there is now a regular production of nickel-speiss, which in 1927 amounted to 1,032 tons, in 1928 to 2,933 tons, and in 1929 to 3,065 tons, the latter production being valued at Rs. 6,38,780 (£47,670). In 1930 there was a further rise to 3,150 tons valued at Rs. 7,26,163 (£53,790). In 1931 the output fell somewhat to 2,911 tons valued at Rs. 6,73,973 (£49,924), and containing 27·63 per cent. of nickel, 10·75 per cent. of copper, and 32·32 ozs. of silver to the ton. This speiss is shipped to Hamburg for further treatment. It contains from 3 to 4 per cent. of cobalt.

Petroleum.

The world's production of petroleum in 1926 amounted to nearly 150 million long tons, of which India contributed 0·72 per cent. In 1927, this figure jumped to some 172 million long tons, of which the Indian proportion, on a practically stationary production, fell to 0·64 per cent. In 1928, there was another substantial rise in the world's production, which reached the figure of over 181 million tons. In 1929, there was another jump to over 202

million tons, but in 1930 the world's production fell to about 193½ million tons and in 1931 to about 188 million tons. The United States alone showed a fall greater than the total fall. Increases were shown by Russia (and Sakhalin), Roumania, Argentina, Trinidad, Japan (including Taiwan), Ecuador, Germany, Canada, Czecho-Slovakia and Italy; Russia showed the largest increase. But all other producers including India showed a decrease in production. The United States contributed 62·1 per cent. of the world's supply in 1931, Venezuela 8·7 per cent. and Russia 11·8 per cent. In 1928, India contributed 0·61 per cent., which fell to 0·60 per cent. in 1929 and rose to 0·62 in 1930 and 0·63 per cent. in 1931; her position on the list of petroleum producing countries fell from 11th in 1929 to 12th in 1930 and in the year under review, her place being taken by Trinidad.[1]

Although petroleum statistics indicate that it is becoming more and more difficult to maintain the output of India (including Burma) at the high levels reached in 1919 and 1921, when peak productions of well over 305½ million gallons were reached, the production thereafter falling to 281,113,909 gallons in 1927, yet the production during 1928 reached the figure of 305,943,711 gallons, in 1929 the figure of 306,148,093 gallons and in 1930 the figure of 311,030,108 gallons, the 1930 totals being the highest ever recorded. The 1931 production showed a fall to 305,018,751 gallons. The decrease in 1931 represents the balance of considerable decreases in the output of Burma and the Punjab and of a very large proportionate increase in the production of Assam to a figure not previously approached. This decrease in output in 1931 was accompanied by an increase in value amounting to Rs. 66,37,438 (£491,662) or 12·6 per cent.

After six years in which decline in production has been in evidence in the Yenangyaung field, this most highly developed field in the Indian Empire again shows a slight recovery amounting to some 540,000 gallons. This recovery includes 2,167,168 gallons of natural gasoline and is attributable principally to the high yields obtained from the Burmah Oil Company's east flank wells. It is interesting to note that the production in Yenangyaung still includes oil derived from the old Burmese hand-dug wells. This oil enjoys a sheltered market and the price at the river bank varied from Rs. 8 to Rs. 10 and annas 12 per 100 viss during the year.

[1] Compiled from '*The Petroleum Times*' of 5th March, 1932.

In the Yenangyaung field 175 wells were drilled during the period under review. The average initial production obtained from them was approximately 15 barrels per well per day. In addition some 150 wells were deepened during the year and yielded an average initial production of approximately 12 barrels per day. Initial productions in excess of 50 barrels per day were obtained in 19 wells, all of which are situated in leased blocks, where development has not been so intensive as in the native reserves.

At the end of the year there were 3095 producing wells in the Yenangyaung field including 162 hand-dug wells, as against 2949 producing wells, including 174 hand-dug wells, in 1930. The exploitation of the shallow sands, which were originally drilled through without protection in the competitive rush for deeper sands, has remained a prominent feature of development. Approximately two-thirds of the new wells drilled during the year were completed in these shallow zones and this source of production yielded approximately 14 per cent. of the total production of the field, compared with approximately 15 per cent. in 1930.

The maintenance of optimum pressure conditions in the leased blocks of the Yenangyaung field is the subject of continuous study and has become an important factor in the conservation of gas. During the year the Burmah Oil Company completed the installation of a new high pressure absorption plant, which, it is anticipated, will contribute to the more efficient extraction of gasoline from the natural gas produced by wells operated by this Company.

As in recent years, very little contribution was made to our knowledge of deeper horizons in the field. B. O. C. well No. 1506 in Block 6S reached a depth of 5,390 feet, which is the greatest depth yet reached in the Yenangyaung field. Owing to difficulties connected with high pressures and associated phenomena, attempts to continue this well to still greater depths have been temporarily abandoned, and the well is at present producing from a depth of approximately 5,000 feet.

Important easterly extensions of the 2,500-2,800 foot sands were proved during the year, and the Burmah Oil Company's east flank development remains the most prolific source of new production. Three new wells have been completed south of the Minlindaung fault, but the expectations based on the results obtained in B. B. D. D. C. well No. 4 have as yet failed to materialise.

In 1931 there was a decrease approaching 10 million gallons in the output of the Singu field, but the greater part of the field is in the hands of the Burmah Oil Company, who use this field to make good the deficiencies of Yenangyaung in order to stabilise supplies to the refinery. The substantial decrease in the production obtained from the field in 1931 should not, therefore, be correlated with any abnormal decline in the productivity of the sands. During the year under review some 30 wells were completed in this field and yielded an average initial production of 43 barrels of oil per well. In addition some 15 wells were deepened and yielded an average initial production of approximately 35 barrels of oil per well. At the end of the year the total number of producing wells was 489. In addition a large number of wells remained cemented above productive sands. These wells can be drilled into the productive sands in a very short time and the total field production substantially increased. Many wells are producing from the 3,000 foot sand.

As in the previous year little contribution was made to our knowledge of deeper horizons. Hessford Development Syndicate's well No. 2 in Block 57N, which reached a depth of 5,878 feet in 1930, remained the deepest well in the Singu field, and in Burma.

As in the case of the Yenangyaung field, the installation of a new high pressure absorption plant by the Burmah Oil Company is an important step in the utilisation of the petrol-forming fractions contained in the gas produced by the Company's wells.

Drilling was first started on the Yenangyat field in 1891 by the Burmah Oil Company. The expansion was slow up to 1894, but rose rapidly to a yield of over 6 million gallons in 1898, and in 1903 the highest quantity recorded from this field was produced, namely 22,665,518 gallons. Subsequent to that year, a decline set in, gradual at first, but severe after 1906. Between 1909 and 1918, production averaged a little over 5 million gallons. From 1918 onwards, the decline was gradual but persistent until 1925, when the output had sunk to a little more than 1½ million gallons. Since 1925, there has been a gradual recovery. In 1927, the output was 1,844,946 gallons. In 1928, the yield rose to 3,072,222 gallons, due to increased drilling on the part of the Burmah Oil Company, and also to expansion by the Indo-Burma Petroleum Company in the Lanywa area in the south; in 1929 the yield rose to 17,606,935 gallons and in 1930 to 19,877,276 gallons due to in-

creased production from Lanywa. In 1931 a decline in the production of the Lanywa field is reflected in a slight decline in the production of the Pakokku district, which amounted to 19,809,104 gallons. In the Yenangyat field proper 23 wells were completed during the year, with an average initial production of approximately 10 barrels. At the end of the year there were 136 producing wells in the field. No oilsands of outstanding value were discovered in either of the deep tests in operation in this field during the year, but a valuable gas sand was encountered in one of them.

It has long been recognised that the Lanywa oilfield is structurally more closely related to the Singu than to the Yenangyat structure, and in September, 1929, the Lanywa area was notified as part of the Chauk oilfield. The embankment for the protection of the Lanywa—Sitpin sandbank was completed in 1929, and by the end of 1930 there were 17 producing wells in this field and the production for the year amounted to approximately 440,000 barrels or 17,760,000 gallons. Sixteen wells were drilled in this field during 1931 and at the end of the year there were 30 producing wells with a total production of 16,437,000 gallons. The wells are producing from sands between 1,700 and 2,500 feet. At the end of the year the drilling of 9 more wells was in progress. The work of filling-in behind the embankment, with the object of rendering the area permanently above high-water level, was continued and at the end of the year preparations were in hand for extending the embankment. As remarked before, the striking of remunerative supplies of oil at Lanywa makes it almost certain that the Irrawaddy river covers oil deposits of commercial value. The question of reaching these deposits by tunnelling beneath the river with chambers large enough to accommodate drilling derricks is still under consideration.

Of the other fields in Burma, Minbu again showed an increased decline amounting to approximately a million gallons and three hundred and forty seven wells were producing in this field at the end of the year. The deep test on the Yethaya portion of the structure was continued to approximately 5.000 feet without obtaining commercial production, and was abandoned during the early part of the year.

There were 39 producing wells in the Indaw field, the production of which showed a slight decrease. The deep test well in this field, which reached a depth of 2,683 feet during 1930, was continued to

2,994 feet, where, however, it was abandoned owing to drilling difficulties.

The Thayetmyo fields, which had shown a large decline in 1928, amounting to over 272,000 gallons, showed in 1929 a small increase of some 19,000 gallons; but in 1930 there was a further substantial decrease in production amounting to some 242,000 gallons. During 1931 activities were considerably hampered by the disturbed conditions prevailing in the district but an increase of some 74,000 gallons was shown in the production of these fields.

The output from Kyaukpyu remained at its usual low level.

In addition to test wells situated in producing fields in Burma others were being drilled at Palusawa (Lower Chindwin), Ainggyi and Shanzu (Magwe district), Natmi, Monatkon and Minhla (Thayetmyo district) Pagan Hills (Myingyan district) and Leya (Pakokku district).

In Assam the output of the Digboi field increased by rather less than 9½ million gallons. The eastern extension well at Hansapung continued to give good though diminishing production. A second extension well in this area was completed at the end of the year; initial production was fairly good, but (as expected) considerably below that of the previous well. The deep test in the Digboi part of the field was disappointing, as it reached an overthrust fault at an unexpectedly shallow depth, after proving only a small thickness of new oilsands. Extension wells in the south and west have continued disappointing. Operations at Baragolai remained suspended.

In the Surma Valley the output from the Badarpur field decreased by almost 850,000 gallons, due to the natural decline of the oilsands, which could no longer be offset by drilling and reconditioning. At Masimpur no oil was produced during the year. The new well referred to in the last year's review was commenced in August. At Patharia about 150,000 gallons of oil were produced from the original well during preparations to deepen. The well was carried down a short distance but was not in good shape and the latter part of the year was taken up with reconditioning work. Well No. 2 has remained shut down.

In the Punjab, the output from the Khaur field showed a decline amounting to just over 2 million gallons, or about 25 per cent. This decline was due to the fact that no important new supply was obtained from the deep sands during the year.

TABLE 24.—*Quantity and value of Petroleum produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur . .	2,841,381	7,10,345	52,618	1,985,042	3,12,644	23,159
Digboi . .	43,968,666	75,08,043	556,151	53,407,990	91,19,891	675,548
Masimpur . .	520	130	10	..	..	..
Patharia . .	3,314	828	61	153,431	24,165	1,789
Burma—						
Kyaukpyu . .	14,616	13,277	984	13,068	11,829	876
Minbu . .	5,038,476	8,18,752	60,648	3,993,633	7,98,726	59,165
Singu . . .	95,368,470	1,54,97,376	1,147,954	85,478,878	1,70,95,676	1,266,346
Thayetmyo . .	503,811	81,869	6,064	577,840	1,15,568	8,561
Upper Chindwin .	2,858,096	2,14,357	15,879	2,777,102	2,09,427	15,513
Yenangyat (including Lanywa).	19,877,276	40,37,572	299,079	19,809,104	39,61,821	293,468
Yenangyaung .	132,893,282	2,16,99,713	1,607,386	131,265,443 (*a*)	2,60,96,073	1,933,043
Punjab—						
Attock. . .	7,662,200	19,15,550	141,893	5,557,720	13,89,430	102,921
Total .	311,030,108	*5,24,97,812*	*3,888,727*	305,018,751	*5,91,35,250*	*4,380,389*

(*a*) Excludes 2,167,468 gallons of natural gasoline.

TABLE 25.—*Imports of Kerosene Oil into India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Russia . .	11,407,382	56,61,482	419,369	3,021,170	15,54,948	115,181
Georgia . .	19,156,236	1,03,48,121	766,527	19,455,551	98,51,423	729,735
Azerbaijan . .	15,676,580	75,06,223	556,017	11,753,288	51,87,107	384,230
Persia . . .	25,964,626	1,33,29,372	987,361	11,001,437	51,71,125	383,046
Straits Settlements (including Labuan).	3,053,601	17,02,056	126,078	428,338	2,16,949	16,070
Borneo . .	1,888,338	11,90,870	88,213	2,235,007	11,40,750	84,500
United States of America.	22,750,506	1,50,45,779	1,114,502	19,599,798	1,27,53,851	944,730
Other countries .	8,592,127	43,85,623	324,861	5,502,450	28,08,569	208,042
Total .	108,489,39 .	*5,91,69,526*	*4,382,928*	72,997,029	*3,86,84,722*	*2,865,534*

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TABLE 26.—*Imports of Fuel Oils into India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
From—	Gals.	Rs.	£	Gals.	Rs.	£
Persia . . .	72,703,388	1,38,45,060	1,025,560	72,294,288	1,41,86,000	1,050,882
Straits Settlements (including Labuan).	9,571,206	19,32,115	143,120	2,665,515	5,41,717	40,127
Borneo . .	24,084,140	51,00,332	381,469	25,681,729	54,28,436	402,106
Other countries .	1,223,402	4,87,815	36,134	3,672,058	8,78,497	65,074
Total .	107,582,226	*2,14,55,322*	*1,589,283*	104,313,690	*2,10,35,550*	*1,558,189*

TABLE 27.—*Exports of Paraffin Wax from India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
To—	Tons	Rs.	£	Tons	Rs.	£
United Kingdom .	10,952	54,60,870	404,509	15,314	68,84,084	509,932
Germany . .	1,817	8,41,766	62,353	780	3,32,220	24,609
Netherlands .	3,340	15,83,050	117,263	2,916	12,65,954	93,774
Belgium . .	3,942	19,03,825	141,024	2,850	12,46,350	92,322
Spain . . .	2,229	10,81,140	80,085	900	3,78,000	28,000
Italy . . .	1,660	7,42,291	56,166	2,995	12,57,900	93,178
China . . .	7,171	36,39,492	269,592	6,045	28,42,014	210,522
Union of South Africa.	2,720	13,37,943	99,107	3,082	14,48,340	107,284
Portuguese East Africa.	5,020	28,59,220	211,794	3,720	20,31,771	150,502
United States of America	7,900	35,75,250	264,833	5,630	24,00,300	177,800
Chile . . .	2,250	10,43,000	77,259	2,516	11,88,740	88,055
Australia . .	820	3,75,390	27,807	293	1,25,790	9,318
New Zealand .	256	1,16,200	8,607	63	37,000	2,790
Other countries .	10,998	52,51,736	389,018	4,459	18,98,755	140,649
Total .	[illegible],19	*2,98,31,182*	*2,209,717*	51,663	*2,33,37,917*	*1,728,735*

There was a great decrease ($35\frac{1}{2}$ million gallons) in the imports of kerosene, due to decreases in the imports from all sources, except small increases from Georgia and Borneo. Imports from the United States of America, which fell from over $60\frac{1}{4}$ million gallons in 1927 to not quite 17 million gallons in 1928, and recovered slightly to $23\frac{1}{2}$ million gallons in 1929, fell to $22\frac{3}{4}$ million gallons in 1930 and to $19\frac{1}{2}$ million gallons in 1931. The decrease from the Straits Settlements amounted to nearly $2\frac{1}{2}$ million gallons, continuing the decrease of nearly 6 million gallons of the previous year. Imports from Persia fell from nearly 26 million gallons in 1930 to 11 million gallons.

The quantity of fuel oil imported into India during 1931 was, as Table 26 will show, over $3\frac{1}{4}$ million gallons less than that received during the previous year, the total imports for the year under review being a little over 104 million gallons. Some 71 per cent. of the supply was derived from Persia and some 25 per cent. from Borneo.

The exports of paraffin wax again showed a decrease of some 9,600 tons. (*See* Table 27.)

Ruby, Sapphire and Spinel.

A severe fall in the output from the Mogok ruby mines of Upper Burma in 1924, followed in 1925 by a marked drop in value bore witness to a serious decline in the industry. The Burma Ruby Mines, Limited, ultimately decided to go into liquidation, and the mines were offered for sale in September, 1926. The skeleton organisation left in charge of the mines, however, made good use of its opportunities, with the result that the value of the output in 1926 exceeded that of the previous year by over a *lakh* of rupees. This encouraging result was effected by a rigorous economy and an extension of a system of co-operation with local miners, and was assisted by some good finds of sapphires in the Kyaungdwin mine—the only one still worked by European methods.

During 1927, however, production fell in value by over $1\frac{3}{4}$ *lakhs* of rupees, due mainly to a decrease in the value of the sapphires and spinels produced, there having been a slight increase in the value of the rubies. During 1928, there was another very large decline in value, amounting to over a *lakh* of rupees, due to a severe drop in the value of the sapphires produced; as before, there was a slight increase in the value of the rubies. The value of the 1929

production was slightly above that of 1928, due to a considerable increase in the value of the rubies found, largely balanced by another large fall in the value of sapphires produced. In 1930 there was a further substantial fall in production and in total value, though the value per carat of the sapphires produced is the highest recorded for many years. Judging from reports in the *Rangoon Times*, this is due to the opening up by the Burma Ruby Mines, Ltd., of the new Pagoda mine at Kathe, leading to the find of a fine sapphire of 630 carats and a star sapphire of 293 carats. The find of a ruby of 100 carats was also reported. The great drop in production recorded in 1931 appears to be due to the cessation of operations of the Burma Ruby Mines, Limited. Though the industry is in a very depressed state, work is still continued by local miners, but of this no reliable statistics are available.

TABLE 28.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma	25,720 (Rubies).	83,987	6,221	(*a*)	40,364	2,990
	1,586 (Sapphires).	46,812	3,468	(*a*)	2,500	185
	2,784 (Spinels).	356	26	..	..	..
Total	30,090	*1,31,155*	*9,715*	..	*42,864*	*3,175*

(*a*) Not available.

Salt.

There was a large increase in the total output of salt amounting to some 128,000 tons, a very substantial decrease of 88,408 tons from Aden, with a decrease from Bombay and Sind of 29,324 tons, being largely neutralised by a great rise in the output of Madras (213,693 tons) and smaller increases from Northern India (28,317 tons) and Burma (3,751 tons). Imports of salt into India decreased substantially by 155,760 tons, all the countries of origin showing decreases, excepting Aden and Dependencies, imports from which increased by 61,903 tons.

TABLE 29.—*Quantity and value of Salt produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden . . .	374,445	42,69,192	316,236	286,037	31,69,172	234,753
Bombay and Sind .	518,376	25,75,400	190,770	489,052	22,83,669	169,161
Burma . . .	19,223	3,11,458	23,071	22,074	3,48,831	25,839
Gwalior (*a*) . .	25	1,115	83	48	2,647	196
Madras . . .	341,756	19,53,961	144,738	555,449	38,83,234	287,647
Northern India .	457,523	36,30,283	268,910	485,840	39,53,406	292,845
Total .	1,711,348	*1,27,41,409*	*943,808*	1,839,400	*1,36,40,959*	*1,010,441*

(*a*) Figures relate to official years 1930-31 and 1931-32.

TABLE 30.—*Quantity and value of Rock-salt produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range . .	148,306	11,34,540	84,040	136,544	10,44,559	77,375
Kohat . . .	23,005	73,176	5,420	21,123	66,509	4,927
Mandi . . .	4,156	1,03,636	7,677	4,226	1,09,503	8,111
Total .	175,467	*13,11,352*	*97,137*	161,893	*12,20,571*	*90,413*

TABLE 31.—*Imports of Salt into India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
United Kingdom .	51,552	11,19,135	82,899	24,164	5,17,170	38,300
Germany . .	95,161	20,75,999	153,778	43,097	7,90,671	58,568
Spain . . .	71,115	15,09,302	111,800	27,264	4,94,683	36,648
Aden and Dependencies.	211,245	34,03,223	252,090	273,148	40,90,055	302,967
Egypt . . .	128,396	21,34,254	158,092	41,084	6,44,927	47,772
Italian East Africa	123,189	19,08,442	141,366	109,904	15,30,617	113,379
Other countries .	12,855	2,05,404	15,215	14,092	1,32,451	9,811
Total .	683,513	*1,23,55,759*	*915,240*	532,753	*82,00,574*	*607,449*

Saltpetre.

Although statistics of production of saltpetre in India are no longer available, the export figures may be accepted as a fairly reliable index to the general state of the industry. Excepting a few hundreds of tons required for internal consumption as fertiliser, most of the output is exported to foreign countries. The quantity exported in 1931 amounted to 123,117 cwts. valued at Rs. 9,91,087 (£73,414), against 76,538 cwts. valued at Rs. 7,21,501 (£53,445) in 1930.

A certain amount of nitrate of potash is used for agricultural purposes on the tea gardens of India. During the war, when it was impossible to obtain supplies of imported potash, the amount of locally produced nitrate utilised in this way reached an appreciable figure. The practice continued and the quantities estimated to have been absorbed for fertilising purposes on tea gardens in 1923, 1924, 1925, 1926, 1927, 1928, 1929 and 1930 were 1,000, 1,100, 800, 700, 500, 250, 300 and 800 tons, respectively. In 1931, this figure is estimated to have been 680 tons only. The gradual decrease since the year 1925 is due to the fact that it was found cheaper to employ a mixture of imported sulphate of ammonia and nitrate of potash.[1] The increased consumption in 1930 was due to the nitrate being available at lower rates, and the decrease in 1931 is due to the general curtailment of manurial programmes owing to economic conditions.

TABLE 32.—*Distribution of Saltpetre exported from India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
United Kingdom . .	21,100	2,24,167	16,605	26,499	2,10,274	15,576
Ceylon	48,747	4,13,315	30,616	55,480	3,33,657	24,715
Straits Settlements (including Labuan).	2,539	22,681	1,680	1,701	14,998	1,111
Mauritius and Dependencies	3,367	48,704	3,608	38,379	4,14,614	30,712
Other countries . .	785	12,634	936	1,058	17,544	1,300
Total .	76,538	*7,21,501*	*53,445*	123,117	*9,91,087*	*73,414*

[1] From information kindly supplied by Messrs. Shaw, Wallace & Co.

Silver.

In contrast with the increases in the production of silver from the Bawdwin mines of Upper Burma, amounting to 1,100,291 ozs. recorded during the four years, 1925 to 1928, the following years 1929, 1930 and 1931 were marked by decreases amounting to 121,211 ozs., 226,311 ozs. and 1,153,806 ozs. respectively. These decreases in quantity were accompanied by a small fall of value in 1929 and marked falls in 1930 and 1931. The output of silver obtained as a bye-product from the Kolar gold mines of Mysore showed an increase of some 5,000 ozs.

TABLE 33.—*Quantity and value of Silver produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Ozs.	Rs.	£	Ozs.	Rs.	£
Burma—						
Northern Shan States .	7,054,206	76,87,674	569,457	5,900,400	51,97,367	384,990
Mysore—						
Kolar	17,844	20,894	1,548	22,605	31,867	2,361
Total .	7,072,050	*77,08,568*	*571,005*	5,923,005	*52,29,234*	*387,351*

Tin.

Following on a series of years of practically continuous increase, a slight decrease in the production of tin-ore in Burma has to be reported for the year under review, during which the output amounted to 4,255·2 tons valued at Rs. 35,07,380 (£259,806), against 4,270·9 tons valued at Rs. 45,54,147 (£337,344) in the preceding year. The great decrease in the total value is, of course, due to the great fall in the price of the metal. This decrease in output of 15·7 tons is the balance of an increase from Mawchi in the Southern Shan States, and decreases in the outputs of the other fields. Milling operations were suspended at Mawchi in August 1927 pending the installation of additional plant and further development. Milling was resumed in February 1930 and this explains the large increases last year and this. The figure for 1931 includes 1,695 tons from Mawchi, calculated to be the proportion of tin-ore in 2,974 tons

of concentrates derived from mixed wolfram-scheelite-cassiterite-ore; these concentrates are assumed to contain 43 per cent. of wolfram and 57 per cent. of cassiterite. There is no reported output of block tin.

Imports of unwrought tin decreased from 56,739 cwts. valued at Rs. 62,33,676 (£461,754) in 1930 to 41,969 cwts. valued at Rs. 36,28,556 (£268,782) in 1931; over 98 per cent. of these imports came from the Straits Settlements.

TABLE 34.—*Quantity and value of Tin-ore produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1=Rs. 13·5).		Quantity.	Value (£1=Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Amherst	42·6	49,566	3,672	17·0	17,683	1,310
Mergui	787·6	8,89,990	65,925	497·4	3,96,304	29,356
Southern Shan States .	(a)1,250·0	13,32,500	98,704	(a)1,695·0	13,96,680	103,458
Tavoy	2,181·5	22,72,502	168,333	2,044·8	16,96,213	125,645
Thaton	9·2	9,589	710	1·0	500	37
Total .	4,270·9	*45,54,147*	*337,344*	4,255·2	*35,07,380*	*259,806*

(a) Estimated.

TABLE 35.—*Imports of unwrought Tin (blocks, ingots, bars and slabs) into India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1=Rs. 13·5).		Quantity.	Value (£1=Rs. 13·5).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
From—						
United Kingdom . .	1,430	1,59,213	11,794	733	61,680	4,569
Straits Settlements (including Labuan).	54,796	60,12,504	445,370	41,133	35,58,768	263,612
Other countries . .	513	61,959	4,590	103	8,108	601
Total .	56,739	*62,33,676*	*461,754*	41,969	*36,28,556*	*268,782*

Tungsten.

During the three years 1926 to 1928 there was a fall in the output of wolfram from 1,484 tons in 1926 to 622 tons in 1928, the last being valued at Rs. 2,99,549 (£22,354). In 1929, the output rose again to 1,348·4 tons valued at Rs. 15,16,795 (£113,193) and in 1930 to 2,451·5 tons valued at Rs. 18,09,881 (£134,065) declining slightly to 2,247·7 tons valued at Rs. 8,81,665 (£65,309) in 1931. The production of 1930 was the highest since the collapse of the industry at the end of the war and is close to the figure for 1920 (2,346·2 tons valued at £139,707) both in quantity and value. The figures for 1930 and 1931 include 943 tons and 1,279 tons respectively from Mawchi, calculated to be the proportion of wolfram in concentrates (assumed to contain 43 per cent. of wolfram and 57 per cent. of cassiterite) derived from the mixed wolfram-scheelite-cassiterite-ore.

The output of Tavoy declined from 1,432·8 tons valued at Rs. 10,78,054 (£79,856) in 1930 to 870·4 tons valued at Rs. 3,51,609 (£26,045) in 1931.

TABLE 36.—*Quantity and value of Tungsten-ore produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui	74·7	35,303	2,622	98·3	28,688	2,125
Southern Shan States	(a)943·0	6,95,934	51,550	(a)1,279·0	5,01,368	37,139
Tavoy	1,432·8	10,78,054	79,856	870·4	3,51,609	26,045
Thaton	1·0	500	37	..	..	..
Total	2,451·5	*18,09,881*	*134,065*	2,247·7	*8,81,665*	*65,309*

(a) Estimated.

Zinc.

The production of zinc concentrates by the Burma Corporation, Limited, in the Northern Shan States, fell from 57,620 tons valued

at Rs. 25,73,309 (£190,615) in 1930 to 51,455 tons valued at Rs. 17,23,528 (£127,669) in 1931. The heavy fall in value per ton reflects the worldwide depression. The exports during the year under review amounted to 54,818 tons valued at Rs. 28,41,250 (£210,463), against 64,800 tons valued at Rs. 64,80,075 (£480,005) in the preceding year.

Zircon.

The output of zircon, a mineral obtained as a concurrent product in the collection of ilmenite and monazite in Travancore State, increased from 639·8 tons valued at £4,991 in 1930 to 854·6 tons valued at £7,972 in 1931, along with a considerable increase in the production of ilmenite.

III.—MINERALS OF GROUP II.

Agate.

The agate mines of Rajpipla State, Bombay Presidency, which had not been worked since 1917, were the source in 1929 of an output of 148·7 cwts. valued at Rs. 8,000 (£597). In 1930 and 1931 there was again no production.

Alum.

The output of alum in the Mianwali district, Punjab, amounted to only 478 cwts. valued at Rs. 5,525 (£412) in 1928, whilst in 1929, 1930 and 1931 there was no manufacture owing to the low market rate.

Amber.

The production of amber in the Myitkyina district, Burma, decreased from 29·5 cwts. valued at Rs. 12,020 (£897) in 1928 to 19·6 cwts. valued at Rs. 6,080 (£454) in 1929, and 2·1 cwts. valued at Rs. 730 (£54) in 1930. There was no reported output in 1931.

Apatite.

The production of apatite in the Singhbhum district, Bihar and Orissa, was 22 tons valued at Rs. 3,300 (£244) in 1930 but *nil* in 1931. There was an output in 1930 in the Trichinopoly district, Madras, of 31 tons of apatite valued at Rs. 294 (£22), and of 52·4 tons of "phosphate", but the value of the latter was not reported. The Trichinopoly output of apatite in 1931 was 109 tons valued at Rs. 1,067 (£79).

There was a decrease in the total production of asbestos from 318·4 tons valued at Rs. 16,160 (£1,206) in 1929 to 33·2 tons valued at Rs. 1,190 (£88) in 1930. This was entirely derived from the Cuddapah district, Madras. The mines in Mysore and Seraikela State were not worked in 1930, and in 1931 the Cuddapah mines as well ceased producing. A small output of 6 tons valued at Rs. 70 (£5) was reported from the Ajmer-Merwara district during 1931.

Asbestos.

Of the toal production of 5,654 tons of barytes valued at Rs. 43,206 (£3,200), 4,158 tons were produced in the Kurnool district, 1,335 tons in the Cuddapah district, Madras and 161 tons in the Alwar State, Rajputana. The production in 1930 amounted to 6,797 tons valued at Rs. 49,562 (£3,671).

Barytes.

In 1930, 2,514 tons of bauxite valued at Rs. 20,112 (£1,490) were produced, of which 719 tons came from the Kaira district of Bombay, and 1,795 tons from the Jubbulpore district of the Central Provinces. In 1931 no bauxite was mined.

Bauxite.

In Jaipur State, Rajputana, 20 cwts. of beryl were extracted in 1930; no value was reported. There was no output in 1931.

Beryl.

The production of native bismuth from the Tavoy district, Burma, fell from 112 lbs. valued at Rs. 323 (£24) in 1930, to 42 lbs. valued at Rs. 84 (£6) in 1931.

Bismuth.

Borax is sometimes produced from the Puga valley in the Ladakh *tahsil* of Kashmir State, but there was no production during the years 1930 and 1931.

Borax.

The total estimated value of building materials and road-metal produced in the year under consideration was Rs. 1,14,98,509 (£851,741). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight.

Building Materials and Road-metal.

There was a decrease in the recorded production of clays, which fell from 180,319 tons valued at Rs. 3,81,839 (28,284) in 1930 to 169,593 tons valued at Rs. 3,45,805 (£25,615). All provinces showed decreases except Madras, Rajputana and the Punjab, and the production of Assam was not recorded last year.

Clays.

TABLE 37.—*Production of Building Materials and*

—	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Assam . . .	10,304	25,829	18,440	43,531	..	..	41,085	40,746
Bengal . . .	58,790	43,335	..	..	..	..	..	..
Bihar and Orissa .	449,978	4,81,491	1,224	477	136	1,134	663,424	18,58,764
Bombay . . .	..	..	2,761	3,462	..	..	45,656	45,600
Burma . . .	313,047	5,24,052	127,903	2,04,726	..	..	442,817	6,24,209
Central India . .	..	..	..	..	11,971	1,05,983	96,469	58,151
Central Provinces .	20,008	29,583	2,462	4,974	..	..	362,746	5,62,260
Gwalior . . .	..	..	..	..	..	..	29,670	20,014
Kashmir . .	..	..	..	..	662	576	..	..
Madras . . .	211,203	3,18,506	63,162	60,263	..	..	13,215	8,390
Mysore . . .	3,793	92,453	214	42	7,205	1,28,882	3,735	22,808
N.-W. F. Province .	..	..	..	..	..	..	7,709	2,842
Punjab . . .	137,170	1,50,614	..	..	..	..	283,844	3,47,071
Rajputana . .	..	..	..	..	..	..	(a)148,114	2,17,384
United Provinces .	..	..	..	..	..	..	(b)754,128	5,52,336
TOTAL .	1,213,293	*16,65,863*	216,166	*3,17,475*	19,974	*2,36,575*	2,887,612	*38,60,635*

(a) Includes 7 tons of dolomite produced in Jaisalmer State.
(b) Includes 733,745 tons of *Kankar*.

Road-metal in India during the year 1931.

MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.		Total Value (£1 = Rs. 13·5).	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Rs.	£
..	..	15,962	27,007	..	..	..	..	305,027	5,09,384	6,46,447	47,885
..	..	..	..	..	..	..	..	..	..	43,335	3,210
..	..	48,927	47,710	2,233	67,974	63,181	60,520	98,352	42,899	20,60,969	152,664
..	..	..	..	..	..	524,694	9,83,756	64,676	74,381	11,07,199	82,015
..	..	176,930	2,00,159	..	..	..	..	1,034,312	11,97,655	27,50,861	203,768
..	..	8,451	39,273	..	..	..	..	117	17	2,03,424	15,068
..	..	..	..	..	..	..	..	22,242	22,427	6,19,244	45,870
..	..	17,860	26,815	..	..	..	..	..	..	46,829	3,469
..	..	..	..	..	..	..	..	9,876	12,043	12,619	935
..	..	..	..	..	..	..	..	392,768	2,01,915	5,89,074	43,635
..	..	1,085	4,463	..	..	6,672	6,708	102,151	88,055	3,43,411	25,438
..	..	..	..	..	..	..	..	..	..	2,842	210
..	..	..	..	5,766	1,23,790	..	..	3,009	2,648	6,29,123	46,602
4,075	1,44,030	164,774	6,18,464	315	1,290	..	..	15,107	25,505	10,06,673	74,568
..	..	2,641	3,103	386	4,139	..	..	576,270	8,76,381	14,36,459	106,404
4,075	*1,44,030*	436,630	*9,66,994*	8,700	*2,02,193*	594,547	*10,50,984*	2,623,907	*30,63,760*	*1,14,98,509*	*851,741*

TABLE 38.—*Production of Clays in India during the year 1931.*

—	1931.		
	Quantity.	Value (£1=Rs. 13·5).	
	Tons.	Rs.	£
Assam	19,486	19,486	1,443
Bengal	22,005	33,155	2,456
Bihar and Orissa	22,501	1,87,576	13,895
Burma	20,825	28,178	2,087
Central India	1,045	3,620	268
Central Provinces	35,865	24,884	1,843
Delhi	2,553	1,936	143
Gwalior	377	1,459	108
Kashmir	11	11	1
Madras	5,196	2,705	200
Mysore	23,640	29,552	2,190
Punjab	11,852	1,852	137
Rajputana	4,237	11,391	844
TOTAL	169,593	*3,45,805*	*25,615*

Columbite.

An output of 100 lbs. of columbite valued at Rs. 60 (£4) was reported from the Monghyr district, Bihar and Orissa, during 1931.

Corundum.

The production of corundum in the Salem district, Madras, amounted to 30 tons valued at Rs. 2,189 (£162) in 1930, but there was no production during 1931.

Felspar.

There was an output of 334 tons of felspar valued at Rs. 3,335 (£247), of which 333 tons came from Ajmer-Merwara, and only 1 ton from Alwar State, Rajputana.

Fuller's earth.

The reported production of Fuller's earth decreased from 4,431 tons in 1930 to 2,958 tons in 1931. The small output from Jubbulpore was doubled, but that from Jodhpur, Bikaner and Hyderabad (Sind), the principal producers, greatly decreased, and in the case of Mysore ceased.

TABLE 39.—*Quantity and value of Fuller's earth produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs.	£	Tons	Rs.	£
Bombay—						
Hyderabad (Sind) . .	909	3,089	229	473	10,453	774
Central Provinces—						
Jubbulpore . . .	19	93	7	38	186	14
Mysore State . . .	280	294	22	..	..	..
Rajputana—						
Bikaner State . . .	1,754	10,582	784	1,146	8,098	600
Jaisalmer State . .	19	276	20	15	178	13
Jodhpur State . . .	1,450	18,000	1,333	1,286	15,400	1,141
Total .	4,431	*32,334*	*2,395*	2,958	*34,315*	*2,542*

Garnet.

There was an output of 7·3 tons of garnet valued at Rs. 175 (£13) in Jaipur State, Rajputana, in 1930. The last recorded production of this mineral was 480 tons of garnet sand valued at Rs. 1,200 (£90) in 1928, from the Tinnevelly district, Madras. In 1931 no garnet was produced in India.

Graphite.

There was an output of 6·5 tons of graphite in the Kistna district of Madras in 1931. The value has not been reported.

Gypsum.

There was a small decrease in the output of gypsum from 56,316 tons valued at Rs. 1,13,512 (£8,408) in 1930, to 53,632 tons valued at Rs. 97,938 (£7,254) in 1931.

TABLE 40.—*Quantity and value of Gypsum produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs.	£	Tons	Rs.	£
Kashmir State	84	65	5	59	65	5
Madras— Trichinopoly	42	(*a*) 546	40	4	41	3
Punjab— Jhelum	14,567	19,871	1,472	16,792	18,102	1,341
Rajputana— Bikaner State	25,452	51,109	3,786	19,572	35,029	2,595
Jaisalmer State	171	921	68	205	1,201	88
Jodhpur State	16,000	41,000	3,037	17,000	43,500	3,222
Total	56,316	*1,13,512*	*8,408*	53,632	*97,938*	*7,254*

(*a*) Estimated.

Miscellaneous refractory minerals.

The output of kyanite and quartzite and related rocks in Bihar and Orissa is becoming increasingly important, partly for purposes of export, and partly for use in India, such as for furnace linings at Jamshedpur, but in 1931 showed a fall to a quarter of the 1930 output. The data for these years, which all relate to the Singhbhum district, except for 3 tons of kyanite produced in Ajmer-Merwara, Rajputana, are assembled in Table 41, from which it will be seen that there has been a decrease in total output from 40,143 tons valued at Rs. 2,09,039 (£15,484), to 9,716 tons valued at Rs. 68,963 (£5,108) in 1931. The most valuable of these materials is kyanite extracted for export by the Indian Copper Corporation from Lapso Hill in Kharsawan.

TABLE 41.—*Quantity and value of Miscellaneous Refractory Materials produced in Bihar and Orissa during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs.	£	Tons	Rs.	£
Kyanite	8,641	1,31,505	9,741	(*a*) 3,412	48,928	3,624
Quartz-kyanite-schist	321	4,173	309	..	..	..
Quartz-mica-schist	2,257	22,570	1,672	1,544	8,589	636
Quartzite	28,924	50,791	3,762	4,760	11,446	848
Total	40,143	*2,09,039*	*15,484*	9,716	*68,963*	*5,108*

(*a*) Includes 3 tons of kyanite produced in Ajmer-Merwara, Rajputana.

Ochre.

There was a large decrease in the production of ochre, which amounted to 4,951 tons, valued at Rs. 25,895 (£1,918) in 1931 against 7,611 tons valued at Rs. 53,345 (£3,951) in 1930 This decrease is due to Central India, there being a considerable rise in output from the Central Provinces, the only other large producer, and trifling rises and falls in the other minor sources.

TABLE 42.—*Quantity and value of Ochre produced in India during the years 1930 and 1931.*

—	1930			1931.		
	Quantity	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs	£	Tons	Rs.	£
Central India . .	4,499	36,522	2,705	864	3,360	249
Central Provinces . . .	1,954	7,389	547	2,828	11,693	866
Gwalior . . .	451	4,263	316	567	5,636	419
Madras	375	4,070	300	300	3,550	263
Rajputana	332	1,121	83	312	1,076	80
United Provinces . . .	..	..	..	80	560	41
Total .	7,611	53,345	3,951	4,951	25,895	1,918

Pyrite.

There was an output of 23 tons of pyrite in Patiala State, Punjab, in 1930. The value was not reported. The return for 1931 has not been received.

Serpentine.

The figures of production of serpentine in the Skardu *tahsil*, Kashmir State, amounting to 1·8 tons valued at Rs. 75 (£6) reported for 1930, were identical with those for 1929 and 1928. The same value has been recorded in 1931, but the quantity produced has not been stated.

Soda.

A production of 14·7 tons of soda valued at Rs. 533 (£39) was reported from the Ladakh *tahsil*, Kashmir State, in both 1929 and 1930. The output reported for 1928 was 11 tons valued at Rs. 533 (£40), and in 1931 also, 11 tons valued at Rs. 412 (£31). Salt, consisting for the greater part of sodium carbonate, sodium bicarbonate and sodium chloride, used to be obtained by evaporation from the waters of the Lonar Lake, in the Buldana district of Berar, in the Central

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Provinces. It was known under the general name of *trona* or *urro*, for which there is no suitable equivalent in English. The total amount of *trona* extracted in 1926 was 100 tons, the value of which was estimated at Rs. 3,000 (£221); as the company working the concession went into liquidation there has been no further reported production until 1930, for which the output was 100 tons valued at Rs. 950 (£70). There was no production in 1931.

Steatite.

There was a decrease in the production of steatite, which fell from 6,857 tons valued at Rs. 2,06,086 (£15,266) in 1930, to 5,135 tons valued at Rs. 1,21,508 (£9,001) in 1931. This was due to the practical extinction of the Jubbulpore output; the only other large producer, Jaipur, remaining almost the same, and the small producers showing negligible variations.

TABLE 43.—*Quantity and value of Steatite produced in India during the years 1930 and 1931.*

—	1930.			1931.		
	Quantity.	Value (£1 = Rs. 13·5).		Quantity.	Value (£1 = Rs. 13·5).	
	Tons	Rs.	£	Tons	Rs.	£
Bihar and Orissa—						
Mayurbhanj	41	3,950	293	27	2,000	193
Seraikela State	12	610	47	37	1,000	74
Singhbhum	208	3,196	259	412	7,746	574
Central India—						
Bijawar State	33	1,350	100	74	1,200	89
Central Provinces—						
Jubbulpore	2,209	30,327	2,246	188	4,077	302
Madras—						
Nellore	35	1,910	142	50	1,000	74
Salem	220	3,485	258	147	3,075	228
Mysore	110	562	42	79	574	43
Rajputana—						
Ajmer-Merwara	15	105	8	25	169	12
Jaipur State	3,927	1,58,225	11,720	3,915	93,884	6,954
United Provinces—						
Hamirpur	47	2,033	151	151	6,183	458
Total	6,857	*2,06,086*	*15,266*	5,135	*1,21,508*	*9,001*

Sulphate of ammonia.

Hitherto, figures of production of ammonium sulphate as a bye-product at the coking plants of iron and steel works and collieries have been collected only every five years for the quinquennial reviews of mineral production. They prove, however, to be of such general interest that it is proposed now to report them annually, and the figures for 1930 and 1931 are shown in Table 44. Values have not been obtained, and ammonium sulphate will not therefore find a place in Table I. The figures show a decrease in production from 16,131 tons in 1930 to 12,133 tons in 1931. The exports for these two years were 4,850 tons and 3,001 tons respectively.

TABLE 44.—*Production of Sulphate of Ammonia in India during the years 1930 and 1931.*

—	1930.	1931.
	Tons.	Tons.
(1) The Bengal Iron Co., Ltd.	1,914	718
(2) The Oriental Gas Co., Ltd.	287	132
(3) The Eastern Coal Co., Ltd.	455	279
(4) The Tata Iron and Steel Co., Ltd.	6,033	5,701
(5) The Indian Iron and Steel Co., Ltd.	3,827	2,155
(6) The Lodna Colliery Co. (1920), Ltd.	700	392
(7) The Burrakur Coal Co., Ltd.	1,203	1,291
(8) The East Indian Railway Colliery, Giridih	347	270
(9) The Bararee Coke Co., Ltd.	1,365	1,195
TOTAL	16,131	12,133

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 45.—*Statement of Mineral Concessions granted during the year 1931.*

AJMER-MERWARA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	
Ajmer .	(1) Mr. Nusserwanji D. Contractor, Kaisarganj.	Kyanite . .	P. L. .	3·0	5th February 1931.	1 year.
Do. .	(2) Mr. L. Govardhan Lall Rathi, Nasirabad.	Mica . . .	P. L. .	0·5	12th March 1931.	Do.
Do. .	(3) Do. . .	Do. . . .	P. L. .	1·1	4th May 1931.	Do.
Do.	(4) Mr. L. Prag Narain C/o Ice Factory, Ajmer.	Kaolin . .	P. L. . (Renewal).	1·2	2nd July 1931.	6 months.
Do. .	(5) Messrs. Abdul Ghani & Co., Nasirabad.	Mica . . .	P. L. .	2·5	11th August 1931.	1 year.
Do. .	(6) Mr. L. Govardhan Lall Rathi.	Do. . . .	P. L. .	3·8	25th August 1931.	Do.
Do. .	(7) Mr. L. Prag Narain	Kaolin, mica, felspar, greenstone, muscovite or mica powder, garnet and beryl ore.	P. L. . (Renewal).	4·5	13th October 1931.	
Do. .	(8) Mr. Nusserwanji D. Contractor.	Beryl ore and precious stone.	M. L. .	..	7th February 1931.	
Beawar .	(9) Mr. L. Prag Narain	Soapstone . .	P. L. .	3·5	21st March 1931.	1 year.
Do. .	(10) Do. . .	Asbestos . .	P. L. . (Renewal).	5·7	9th June 1931.	Do.
Do. .	(11) Do. .	Ochre and soapstone.	P. L. . (Renewal).	18·9	11th June 1931.	Do.
Do. .	(12) Do. . .	Asbestos . .	P. L. .	11·8	19th June 1931.	Do.
Do. .	(13) Do. . .	Asbestos and soapstone.	P. L. . (Renewal).	3·6	11th September 1931.	6 months
Do. .	(14) Do. . .	Graphite . .	P. L. . (Renewal).	11·7	6th November 1931.	1 year.

ASSAM.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	
Cachar .	(15) The Buddarpur Oil Co., Ltd.	Mineral oil . .	P. L. .	1,388·8	1st November 1929.	2 years.
Do .	(16) The Burmah Oil, Co., Ltd.	Natural petroleum	P. L. .	3,001·6	12th April 1930.	Do.
Do. .	(17) Do. . .	Do. . .	P. L. .	6,160·6	6th April 1931.	Do.
Do. .	(18) Do. . .	Do. . .	P. L. .	1,088·0	3rd December 1930.	1 year.

P. L.=*Prospecting Licence.* M. L.=*Mining Lease.*

ASSAM—*contd.*

District.	Grantee.	Mineral.	of grant.	Area in acres.	Date of commencement.	Term.
Cachar	(19) The Burmah Oil, Co., Ltd.	Natural petroleum	P. L.	2,060·8	1st June 1931.	1 year.
Khasi and Jaintia Hills.	(20) Mr. D. N. Sen		M. L.	2,348·0	1st January 1930.	30 years.
Lakhimpur	(21) The Assam Oil Co., Ltd.		P. L.	5,120·0	30th March 1931.	1 year.
Do.	(22) Do.	Do.	P. L.	3,968·0	12th May 1931.	Do.
Do.	(23) Do.	Do.	P. L.	9,792·0	8th October 1931.	Do.
Do.	(24) Do.	Do.	P. L.	1,792·0	25th October 1931.	2 years.
Do.	(25) Do.	Do.	P. L.	665·6	2nd May 1931.	1 year.
Do.	(26) Do.	Do.	P. L.	1,190·4	8th October 1931.	Do.
Do.	(27) The Assam Railway and Trading Co.	Do.	M. L.	2,560·0	31st July 1931.	30 years.
Sibsagar	(28) Babu Nagendra Nath Roy.	Coal	P. L.	50·0	23rd July 1931.	1 year.
Sylhet	(29) The Burmah Oil Co., Ltd.	Mineral oil	P. L.	9,184·0	5th March 1931.	Do.
Do.	(30) Do.	Do.	P. L.	3,136·0	3rd May 1931.	Do.
Do.	(31) Do.	Do.	P. L.	3,161·6	3rd September 1930.	2 years.
	(32) Do.	Do.	P. L.	9,305·6	1st October 1930.	Do.

BALUCHISTAN.

District.	Grantee.	Mineral.	of grant.	Area in acres.	Date of commencement.	Term.
Quetta-Pishin	(33) Mr. Dinshaw Rustomjee, Parsi Colony, Quetta.	Coal	P. L.	3,200·0	23rd June 1931.	1 year.
Sibi	(34) The Burmah Oil Co., Ltd., Badarpur Ghat.	Natural petroleum	E. L.	491,520·0	19th May 1931.	

BENGAL.

District.	Grantee.	Mineral.	of grant.	Area in acres.	Date of commencement.	Term.
Chittagong	(35) The Burmah Oil Co., Ltd.	Natural petroleum	P. L.	4,000·0	9th March 1931.	2 years.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BIHAR AND ORISSA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Angul	(36) Babu Raja Tricumji.	Ochre	P. L.	637·3	1st January 1931.	1 year.
Hazaribagh	(37) Mr. S. S. Guzdar	Garnet	M. L.	14·1	14th May 1931.	30 years.
Do.	(38) Babu M. K. Ray	Sillimanite and kyanite.	P. L.	51·2	5th December 1931.	1 year.
Palamau	(39) Babu Manjendra Datt.	Graphite	P. L.	27·1	12th October 1931.	Do.
Santal Parganas.	(40) Babu Bansi Ram Marwari of Godda.	Coal	M. L.	5·0	1st April 1931.	2 years.
Do.	(41) Do.	Do.	M. L.	1·0	Do.	Do.
Do.	(42) Do.	Do.	M. L.	0·3	Do.	Do.
Do.	(43) Babu Ganga Ram Marwari.	Do.	M. L.	1·8	Do.	Do.
Do.	(44) Babu Bansi Ram Marwari.	Do.	M. L.	5·0	Do.	Do.
Do.	(45) Do.	Do.	M. L.	5·0	Do.	Do.
Do.	(46) Babu Rameswar Marwari, Daiji, Dumka Town.	Do.	M. L.	2·2	Do.	Do.
Do.	(47) Babu Bansi Ram Marwari.	Do.	M. L.	5·0	Do.	1 year.
Do.	(48) Babu Hem Chandra De, Rasikpur, Dumka.	Do.	M. L.	2·2	Do.	2 years.
Do.	(49) Badu Hem Chandra De.	Do.	M. L.	1·0	Do.	Do.
Do.	(50) Babu Bansi Ram Marwari.	Do.	M. L.	6·0	Do.	Do.
Singhbhum	(51) Babu N. N. Kumar	Chromite	P. L.	1,528·3	5th November 1930.	Six months
Do.	(52) Mr. S. S. Guzdar	All minerals except iron ore, mica and precious stones.	P. L.	548·0	19th February 1931.	Do.
Do.	(53) The Indian Iron and Steel Co., Ltd.	Iron ore and manganese.	M. L.	75·2	10th August 1931.	Up to 11th May 1950.
Do.	(54) Baba Ajat Kumar Mallick.	Chromite	P. L.	408·0	27th August 1931.	1 year.

BOMBAY.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kanara	(55) Messrs. Unwalla Nariman & Co., Bombay.	Manganese ore	P. L.	223·0	13th March 1931.	1 year.
Do.	(56) Mr. K. E. Kotwal, Bulsar.	Asbestos and talc	P. L.	38·8	10th June 1931.	Do.
Ratnagiri	(57) Messrs. Oakley, Duncan & Co., Ltd., Bangalore.	Chromite	P. L.	1,280·0	1st January 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(58) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	4,480·0	28th July 1931.	1 year, 3 months, 4 days.
Do. .	(59) Do. . .	Do. . .	P. L. .	1,280·0	2nd November 1930.	2 years.
Do. .	(60) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	5,440·0	15th December 1930.	1 year.
Do. .	(61) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. (Renewal).	5,056·0	9th May 1931	Do.
Do. .	(62) Do. . .	Do. . .	P. L. (Renewal).	4,352·0	Do. .	Do.
Do. .	(63) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	1,177·6	22nd April 1931.	Do.
Do. .	(64) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. (Renewal).	633·6	30th July 1931.	Do.
Amherst .	(65) Maung On Pe .	All minerals except oil.	P. L. .	1,280·0	5th February 1931.	Do.
Bhamo .	(66) Messrs The Tavoy Tin Syndicate Ltd.	Gold . . .	P. L. (Renewal).	3,232·0	24th October 1931.	Do.
Do. .	(67) Do. . .	Do. . .	P. L. (Renewal).	3,328·0	Do.	Do.
Do. .	(68) Do. . .	Do. . .	P. L. (Renewal).	825·6	Do. .	Do.
Lower Chindwin.	(69) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	5,760·0	5th July 1930.	2 years.
Do. .	(70) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. (Renewal).	640·0	24th January 1931.	1 year.
Do. .	(71) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	825·6	30th July 1931.	Do.
Magwe .	(72) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. .	473·6	17th April 1931.	2 years.
Do. .	(73) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	P. L. .	3,863·7	5th March 1931.	Do.
Do. .	(74) Messrs. The Yenangyaung Oilfield Southern Extension Ltd.	Do. . .	P. L. .	2,880·0	21st December 1931.	Do.
Do. .	(75) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. .	960·0	2nd September 1931.	Do.
Do. .	(76) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	70·4	26th August 1929.	1 year.
Do. .	(77) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	320·0	16th April 1930.	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe .	(78) Mr. A. Rahman .	Natural petroleum (including natural gas.)	P. L. (Renewal).	1,280·0	27th July 1930.	Till the issue of a mining lease.
Do. .	(79) Messrs. The British Burma Petroleum Co., Ltd.	Do. .	P. L. (Renewal)	5,410 0	1st April 1931.	1 year.
Do. .	(80) Do. . .	Do. .	P. L. (Renewal).	15,360·0	11th April 1931	Do.
Do. .	(81) Do. . .	Do. .	P. L. (Renewal).	640·0	23rd July 1931.	Do.
Do. .	(82) Do. . .	Do. . .	P. L. (Renewal).	1 920 0	20th April 1931.	Do.
Mergui .	(83) Mr. Gul Mohamed	Tin and allied minerals.	P. L. .	153·6	18th April 1931.	Do.
Do. .	(84) Mr. Ah Khoon .	Tin ore . .	P. L. .	102·4	15th August 1931.	Do.
Do. .	(85) Mr. G. H. Hand .	Gold tin and allied minerals.	P. L. .	390·1	26th February 1931.	Do.
Do. .	(86) U. E. Gyi . .	Tin and allied minerals.	P. L. .	128·0	22nd May 1931.	Do.
Do. .	(87) Mr. Gul Mohamed	Do. . .	P. L. .	640·0	14th March 1931.	Do.
Do. .	(88) Leong Foke Hye .	Tin . . .	P. L. .	217·6	6th August 1931.	Do.
Do. .	(89) The Malayan and General Trust Ltd.	Do . . .	P. L .	998·4	24th September 1931.	Do.
Do. .	(90) Mr. Kapur Singh	Tin and wolfram .	P. L. .	364·8	20th August 1931.	Do.
Do. .	(91) Do. . .	Do. . .	P. L. .	204·8	22nd October 1931.	Do.
Do. .	(92) Mr. F. Wah Yu .	Tin and allied minerals.	P. L. .	102·4	23rd October 1931.	Do.
Do. .	(93) Mr. E. Ahmed .	Do. . .	P. L. .	275·2	24th August 1931.	Do.
Do. .	(94) Mr. G. H. Hand .	Gold, tin and allied minerals.	P. L. .	268·8	19th September 1931.	Do.
Do. .	(95) Mr. Udhandas .	Tin and allied minerals.	P. L. .	211·2	14th September 1931.	Do.
Do. .	(96) Mr. Gul Mohamed	Do. . .	P. L. .	185·6	13th October 1931.	Do.
Do. .	(97) Eu Gwan Kyin .	Tin ore . .	P. L. .	96·0	5th December 1931.	Do.
Do. .	(98) Mr. Udhandas .	Tin and allied minerals.	P. L. .	550·4	21st September 1931.	Do.
Do. .	(99) Maung San Dun .	Tin . . .	P. L. .	211·2	14th December 1931.	Do.

P. L.=*Prospecting License.*

, BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(100) Mr. Leslie R. Beale	Tin and allied minerals.	P. L. .	326·4	17th November 1931.	1 year.
Do. .	(101) Ah Shee . .	Tin and wolfram .	P. L. .	192·0	14th November 1931.	Do.
Do. .	(102) Mr. P. B. O. Watson.	Tin and allied minerals.	P. L. .	248·2	8th January 1932.	Do.
Do. .	(103) Mr. Udhandas .	Do. . .	P. L. .	236·8	25th November 1931.	Do.
Do. .	(104) Mr. B. B. Jubb .	Tin . . .	P. L. .	172·8	20th August 1931.	Do.
Do. .	(105) Messrs. Holmes and Morgan.	Do. . .	M. L. .	230·4	1st July 1931	30 years.
Do. .	(106) Mr. L. R. Beale .	Tin and allied minerals.	M. L. .	072·8	15th May 1929.	Do.
Do. .	(107) Mr. E. Maxwell Lefroy.	All minerals except oil and precious stones.	P. L. (Renewal). .	403·2	26th October 1930.	1 year.
Do.	(108) Mr. Khoo Tun Byan.	Tin and allied minerals.	P. L. (Renewal). .	345·6	16th November 1930.	Do.
Do. .	(109) Ah Shee . .	Tin . . .	P. L. (Renewal). .	57·6	13th February 1931.	Do.
Do. .	(110) Ma Tin . .	Tin and allied minerals.	P. L. (Renewal). .	256·0	14th February 1931.	Do.
Do. .	(111) The Malayan and General Trust Ltd.	Tin . . .	P. L. (Renewal). .	179·2	4th March 1931.	Do.
Do. .	(112) Mr. Khoo Tun Byan.	Tin and allied minerals.	P. L. (Renewal). .	371·2	20th May 1931.	Do.
Do. .	(113) Eu Gwan Kyan .	Tin . . .	P. L. (Renewal). .	25·6	11th July 1931.	Do.
Do. .	(114) The Malayan and General Trust Ltd.	Tin and allied minerals except mineral oil.	P. L. (Renewal). .	1,900·8	24th August 1931.	Do.
Do. .	(115) Mr. M. Haniff .	Tin ore and other allied metals.	P. L. (Renewal). .	166·4	15th April 1931.	Do.
Do. .	(116) Leong Foke Hye	Tin and allied minerals.	P. L. (Renewal). .	166·4	1st July 1931.	Do.
Do. .	(117) U. E. Gyi . .	Tin, wolfram and allied minerals.	P. L. (Renewal). .	83·2	10th September 1931.	Do.
Do. .	(118) Mr. Khoo Tun Byan.	Tin and allied minerals.	P. L. (Renewal). .	192·0	14th August 1931.	Do.
Do. .	(119) Saw Maung Po .	Tin . . .	P. L. (Renewal). .	230·4	11th September 1931.	Do.
Do. .	(120) Eng Tain Leong	Tin and allied minerals.	P. L. (Renewal). .	339·2	18th September 1931.	Do.
Do. .	(121) Do. . .	Tin . . .	P. L. (Renewal). .	108·8	26th October 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(122) Mr. Mohamed Ghouse.	Tin and allied minerals.	P. L. (Renewal).	435·2	24th October 1931.	1 year.
Do. .	(123) Eng Tain Leong	Tin ore . .	P. L. (Renewal).	57·6	18th December 1931.	Do.
Myingyan .	(124) Dr. A. W. G. Bleek.	Natural petroleum (including natural gas).	P. L. .	640·0	27th January 1931.	2 years.
Do. .	(125) Messrs. The Yenangyaung Oilfield Southern Extension, Ltd.	Do. . .	P. L. .	1,440·0	10th November 1931.	Do.
Northern Shan States.	(126) Messrs. The Burma Corporation, Ltd.	Iron ore . .	M. L. .	40·0	1st March 1931.	30 years.
Do. .	(127) Do. . .	Do. . .	M. L. .	40·0	Do. .	Do.
Do. .	(128) Do. . .	Do. . .	M. L. .	42·8	Do. .	Do.
Do. .	(129) Mr. A. R. Oberlander, Namtu.	Lead and silver ore.	P. L. (Renewal).	320·0	21st August 1931.	1 year.
Pakokku .	(130) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	M. L. .	1,280·0	1st July 1930	30 years.
Do. .	(131) U Po Shwe .	Do. . .	M. L. .	921·6	15th November 1931.	Do.
Do. .	(132) U Thu Daw .	Do. . .	M. L. .	640·0	1st October 1931.	Do.
Do. .	(133) Messrs. The Burmah Oil Co., Ltd.	Do. . .	M. L. .	1,708·8	1st July 1930	Do.
Do. .	(134) Do. . .	Do. . .	M. L. .	960·0	Do. .	Do.
Do. .	(135) Messrs. The Rangoon Oil Co., Ltd.	Do. . .	M. L. .	1,280·0	Do. .	Do.
Do. .	(136) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. (Renewal).	320·0	24th April 1931.	1 year.
Shwebo .	(137) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (Renewal).	5,440·0	14th August 1931.	Do.
Southern Shan States.	(138) Mr. E. G. M. Garrett.	All minerals except mineral oil.	P. L. .	400·0	4th August 1931.	Do.
Do. .	(139) Do. . .	Do. . .	P. L. .	400·0	Do. .	Do.
Do. .	(140) Mr. Abdul Haq .	Wolfram . .	P. L. (Renewal).	960·0	3rd July 1931	Do.
Do. .	(141) Mr. J. W. Ryan	All minerals except oil.	P. L. (Renewal).	1 280·0	27th June 1931.	Do.
Tavoy .	(142) Mr. J. M. Khan	Tin and wolfram .	P. L. .	499·2	20th January 1931.	Do.
Do. .	(143) Mr. D. R. Bowrie	Do. . .	P. L. .	640·0	7th August 1931.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(144) Mr. Quah Hun Cheong.	Tin and wolfram .	P. L. .	64·0	1st September 1931.	1 year.
Do. .	(145) Mr. Yoe Kyi Han	Do. . .	P. L. .	275·2	24th October 1931.	Do.
Do. .	(146) U Ohn Nyun .	Do. . .	P. L. .	608·0	23rd December 1931.	Do.
Do. .	(147) Mr. C. Soo Don .	Do. . .	P. L. .	358·4	24th October 1931.	Do.
Do. .	(148) Messrs. The Tavoy Tin Dredging Corporation Ltd.	Tin . . .	M. L. .	1·9	1st April 1931	30 years.
Do. .	(149) Mr. Khoo Sein Shan.	Tin and wolfram .	M. L. .	416·0	1st February 1931.	Do.
Do. .	(150) Messrs. The Burma Malaya Mines, Ltd.	All minerals except oil and precious stones.	M. L. .	44·8	1st May 1931	Do.
Do. .	(151) Mr. Quah Hun Cheong.	Do. . .	M. L. .	326·4	1st August 1931.	Do.
Do. .	(152) Messrs. The Anglo-Burma Tin Co., Ltd.	All minerals except oil.	M. L. .	1,715·2	1st September 1931.	Do.
Do. .	(153) Do. . .	Do. . .	M. L. .	131·4	1st July 1930	Do.
Do. .	(154) Do. . .	Tin and wolfram .	P. L. (Renewal).	2,281·8	16th August 1930.	1 year.
Do. .	(155) U Ohn Nyun .	Do. . .	P. L. (Renewal).	249·6	28th June 1930.	Do.
Do. .	(156) U Ba Oh . .	Do. . .	P. L. (Renewal).	595·2	14th November 1930.	Do.
Do. .	(157) Mr. H. G. Gregson	Do. . .	P. L. (Renewal).	134·4	7th September 1930.	Do.
Do. .	(158) U Kyaing . .	Do. . .	P. L. (Renewal).	640·0	15th January 1931.	Do.
Do. .	(159) Messrs. The Anglo-Burma Tin Co., Ltd.	Do. . .	P. L. (Renewal).	230·4	1st February 1931.	Do.
Do. .	(160) Mr. Teh Lu Pe .	Do. .	P. L. (Renewal).	89·6	5th June 1931.	Do.
Do. .	(161) U Ohn Nyun .	Do. . .	P. L. (Renewal).	249·6	28th June 1931.	Do.
Do. .	(162) Do. . .	Do. . .	P. L. (Renewal).	320·0	27th June 1931.	Do.
Do. .	(163) U Kyaing. .	Do. . .	P. L. (Renewal).	1,068·8	9th August 1931.	Do.
Do. .	(164) Mr. C. Soo Don .	Do. . .	P. L. (Renewal).	320·0	1st August 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(165) Mr. H. G. Gregson	Tin and wolfram	P. L. (Renewal).	184·4	7th September 1931.	1 year.
Thaton	(166) Mr. A. C. Martin	All minerals except oil.	P. L.	403·2	30th September 1931.	Do.
Thayetmyo	(167) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L.	1,680·0	8th January 1931.	2 year.
Do.	(168) Do.	Do.	P. L.	2,240·0	23rd March 1931.	Do.
Do.	(169) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do.	P. L. (Renewal).	8,960·0	9th February 1931.	1 year.
Do.	(170) Do.	Do.	P. L. (Renewal).	2,339·3	28th April 1931.	Do.
Upper Chindwin.	(171) Messrs. Fairweather Richards & Co., Ltd.	Coal	P. L. (Renewal).	1,827·2	20th October 1930.	Do.
Do.	(172) Do.	Do.	P. L. (Renewal).	1,280·0	Do.	Do.
Do.	(173) Do.	Do.	P. L. (Renewal).	3,686·4	11th March 1931.	Do.
Do.	(174) Do.	Do.	P. L. (Renewal).	701·0	Do.	Do.
Do.	(175) Do.	Do.	P. L. (Renewal).	1,568·8	15th August 1931.	Do.
Do.	(176) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L. (Renewal).	8,320·0	25th June 1931.	Do.
Do.	(177) Do.	Do.	P. L. (Renewal).	640·0	6th October 1931.	Do.

CENTRAL PROVINCES.

Balaghat	(178) Mr. Diwanchand Jiwar.	Manganese	M. L.	17	16th June 1931.	5 years.
Do.	(179) Rai Bahadur Bansilal Abeerchand, Mining Syndicate.	Do.	M. L.	7	8th December 1931.	10 years.
Do.	(180) Mr. M. B. Marfatia.	Do.	P. L.	10	26th May 1931	1 year.
Do.	(181) Do.	Do.	P. L.	51	21st October 1931.	Do.
Bhandara	(182) Mr. Ganpat Sao and Dhanpat Sao.	Red iron oxide and bauxite.	M. L.	30	25th September 1931.	30 years.
Do.	(183) Rai Bahadur Seth Govardhandass of Tumsar.	Manganese	M. L.	20	11th April 1931.	5 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of [illegible]ment.	Term.
Bilaspur .	(184) Messrs. Gurdutt Singh Harnamchand.	Limestone and dolomite.	P. L. .	95	12th May 1931.	1 year.
Do. .	(185) Messrs. Gurbux Singh Uttam Singh.	Limestone . .	P. L. .	60	8th May 1931	Do.
Do. .	(186) Mr. A. H. Wasudeo Rao.	Do. . .	P. L. .	28	17th November 1931.	Do.
Do. .	(187) Mr. Dhanji Kunwarji.	Do. . .	Q. L. .	24	18th June 1931.	10 years.
Do. .	(188) Mr. Mulji Jagmal	Do. . .	Q. L. .	10	21st October 1931.	Do.
Do. .	(189) Messrs. Chandanmull Indra Kumar.	Do. . .	Q. L. .	34	7th September 1931.	Do.
Chanda .	(190) Sir M. B. Dadabhoy of Nagpur.	Coal . . .	P. L. .	3,340	22nd July 1931.	1 year.
Chhindwara	(191) Mr. A. V. Wazalwar, Pleader of Nagpur.	Manganese .	M. L. .	16	11th February 1931.	30 years.
Do .	(192) Mr. B. R. Goenka of Nagpur.	Coal . . .	M. L. .	110	10th November 1931.	Do.
Do. .	(193) Mr. A. V. Wazalwar, Pleader of Nagpur.	Manganese .	P. L. .	40	10th February 1931.	1 year.
Do. .	(194) [illegible]	Coal	P. L. .	361	6th November 1931.	Do.
Do. .	(195) Mr. B. R. Goenka of Nagpur.	Do. . .	P. L. .	110	5th January 1931.	Do.
Do. .	(196) Messrs. The Indian Manganese Co., Ltd., Nagpur.	Manganese . . .	P. L. .	240	15th April 1931.	Do.
Do .	(197) Messrs. S. C. Cambata and Company.	Coal	P. L. .	1,746	4th July 1931	Do.
Do. .	(198) Hirdagar Collieries, Ltd., Nagpur.	Do. .	P. L. .	427	Do. .	Do.
Do. .	(199) Do. .	Do. . .	P. L. .	810	Do. .	Do.
Do. .	(200) Do. .	Do. . .	P. L. .	479	4th August 1931.	Do.
Do. .	(201) Mr. B. R. Goenka of Nagpur.	Do. . . .	P. L. .	1,295	2nd July 1931	Do.
Do. .	(202) Lala Budhoolal Bishan Lal Nath of Gharawari.	Do. . .	P. L. .	503	21st December 1931.	Do.
Do. .	(203) Messrs. S. C. Cambata and Company, Bombay.	Do. .	P. L. .	1,568	4th November 1931.	Do.
Do. .	(204) Seth Hazarimal Bazaz, Chhindwara.	Do. .	P. L. .	888	14th November 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* Q. L.=*Quarry License.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(205) The Katni Cement and Industrial Co., Ltd.	Clay	Q. L. .	24	18th March 1931.	12 years 9 months.
Do. .	(206) Mr. G. Forrester	Laterite . .	Q. L. .	1	21st May 1931	10 years.
Do. .	(207) Mr. E. E. Dutt .	Platinum, silver, gold and vanadium.	P. L. .	520	16th September 1931.	1 year.
Do. .	(208) Do. .	Bauxite, chromium copper, gold, iridium, osmium, palladium, silver, thorium, titanium, rhodium, rubidium and vanadium.	P. L. .	470	7th August 1931.	Do.
Do. .	(209) Do. .	Do. .	P. L. .	28	12th September 1931.	Do.
Do. .	(210) Do. .	Bauxite, osmium, ruthenium, cerium, palladium silver, gold, platinum, thorium, iridium, rhodium and titanium.	P. L. .	60	Do. .	Do.
Do.	(211) Mr. G. H. Cook .	Limestone . .	Q. L. .	1	27th April 1931.	10 years
Do. .	(212) Mr. Jogindra Pail Maitra.	Yellow and red ochre.	P. L. .	13	14th April 1931.	1 year.
Do. .	(213) Messrs. MacPherson and Company.	Limestone . .	Q. L. .	3	17th December 1930.	10 years.
Do. .	(214) The Bauxite Chemical and Development Syndicate, Ltd.	Bauxite, gold, nickel, manganese, platinum, silver and copper.	P. L. .	67,130	25th June 1931.	1 year.
Do. .	(215) Messrs. Rahat Ali M. Salim.	Limestone . .	P. L. .	47	13th April 1931.	Do.
Do. .	(216) Mr. Kalyanji Kachhi.	White clay . .	P. L. .	32	5th November 1931.	Do.
Nagpur .	(217) Mr. A. V. Wazalwar.	Galena . .	P. L. .	105	24th March 1931.	Do.
Do. .	(218) Khan Bahadur M. E. B. Malak.	Clay . . .	Q. L. .	1	8th April 1931	Up to 4th April 1938.
Do. .	(219) Mr. Kurbanali Mainu Miyan.	Do. . . .	Q. L. .	6	16th March 1931.	10 years.
Do. .	(220) Messrs. Kewalram and Chotelal.	Do. . . .	Q. L. .	1	12th November 1931.	Do.
Do. .	(221) Mr. Sudan Umrao, Kumbhar.	Do. . . .	Q. L. .	2	25th August 1931.	Do.

P. L.=*Prospecting License.* Q. L.=*Quarry License.*

CENTRAL PROVINCES—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(222) Messrs. Bhawani and Jagannath Kumbhars.	Clay . . .	Q. L. .	2	22nd June 1931.	10 years.
Do. .	(223) The Central Provinces Manganese Ore Company, Ltd	Manganese ..	M. L. .	103	12th November 1931.	30 years.
Do. .	(224) Do.	Do. . .	M. L. .	1	Do. .	Do.
Do. .	(225) Do. .	Do. . .	M. L. .	21	Do. .	Do.
Do. .	(226) Do. .	Do. . .	M. L. .	205	Do. .	Do.
Do. .	(227) Do. .	Do. . .	M. L. .	99	Do. .	Do.
Do. .	(228) Do. .	Do. . .	M. L. .	14	Do. .	Do.
Do. .	(229) Do. .	Do. . .	M. L. .	135	Do. .	Do.
Do. .	(230) Do. .	Do. . .	M. L. .	44	Do. .	Do.
Do. .	(231) Do. .	Do. . .	M. L. .	57	Do. .	Do.
Do. .	(232) Do. .	Do. . .	M. L. .	26	Do. .	Do.
Do. .	(233) Do. .	Do. . .	M. L. .	1	Do. .	Do.
Do. .	(234) Do. .	Do. . .	M. L. .	54	Do. .	Do.
Do. .	(235) Do. .	Do. . .	M. L. .	50	Do. .	Do.
Do. .	(236) Do. .	Do. . .	M. L. .	1	Do. .	Do.
Do. .	(237) Do. .	Do. . .	M. L. .	14	Do. .	Do.
Do. .	(238) Mr. Jumma Bisan Kumbhar.	Clay . . .	Q. L. .	2	Do. .	10 years.
Do. .	(239) Mr. Trimlak Krishna Kolatkar.	Limestone . .	Q. L. .	2	4th November 1931.	5 years.
Do. .	(240) Sir M. B. Dadabhoy, Kt., C.I.E.	Manganese . .	M. L. .	2	20th August 1931.	Do.
Do. .	(241) R. B. B. A. M. Syndicate.	Do. . .	M. L. .	32	20th August 1931.	10 years.
Raipur .	(242) Mr. Manmohanlal, Contractor.	Flag stone . .	P. L. .	169	18th July 1931.	1 year.
Do. .	(243) Do. .	Do. . .	Q. L. .	21	19th December 1931.	10 years.
Do. .	(244) Messrs. S. C. Bose and Company.	Do. . .	Q. L. .	20	14th December 1931.	Do.

MADRAS.

Anantapur .	(245) Mr. S. S. Guzdar	Barytes . .	M. L. .	131·50	1st October 1931.	30 years.
Do. .	(246) Mr. M. Rajagopal Nayudu.	Do. . .	P. L. .	49·05	26th November 1931.	1 year.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* Q. L.=*Quarry License.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Anantapur .	(247) Khan Sahib Abdul Hye.	Barytes . .	P. L. .	22·10	2nd August 1931.	1 year
Cuddapah .	(248) Mr. Abdul Hakeem.	Do. . .	P. L. .	100·00	11th March 1931.	Do.
Do. .	(249) Mr. Isanaki Ramasubba Reddi.	Manganese . .	P. L. .	241·20	22nd August 1930.	Do.
Do. .	(250) Mr. Thomas Tillin	Barytes . .	P. L. .	132 51	19th December 1930.	Do.
Do. .	(251) Mr. S. S. Guzdar	Do. . .	P. L. .	40·60	29th April 1931.	Do.
Do. .	(252) Do. .	Do. . .	P. L. .	24·30	8th August 1931.	Do.
Do. .	(253) Do. .	Do. . .	P. L. .	9·90	10th December 1931.	Do.
Do. .	(254) Mr. I. Ramasubba Reddi.	Manganese . .	P. L. .	70 00	31st February 1931.	Do.
Do. .	(255) Mr. Thomas Tillin	Barytes . .	P. L. .	39·65	7th December 1931.	Do.
Do. .	(256) Mr. V. Venkatasubbayya.	Do. . .	P. L. .	28·11	3rd August 1931.	Do.
Do. .	(257) Mr. Budhu Venkatasubbayya.	Do . .	P. L.	62·08	14th November 1931.	Do.
Do. .	(258) Mr. A. Krishnappa.	Do. . .	P. L. .	30·21	8th December 1931.	Do.
Kurnool .	(259) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	[illegible]0 00	6th January 1931.	Do
Do. .	(260) Mr. B. P. Sesha Reddi.	Do. . .	M. L. .	10·00	8th April 1931	[illegible]
Do. .	(261) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	32 00	24th January 1931.	1 year.
Do. .	(262) Mr. S. Jayarama Reddi.	Do. .	P. L. .	92·28	6th January 1931.	Do.
Do. .	(263) Do. .	Do. . .	P. L. .	31·70	26th January 1931.	Do.
Do. .	(264) Do. .	Do. . .	P. L. .	42·75	7th February 1931.	Do.
Do. .	(265) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	4·00	28th January 1931.	Do.
Do. .	(266) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	51·00	14th March 1931.	Do.
Do. .	(267) Do. .	Do. . .	P. L. .	77·77	12th May 1931	Do
Do. .	(268) Do. .	Do. . .	P. L. .	42·00	28th January 1931.	Do.
Do. .	(269) Do. .	Do. . .	P. L. .	138·80	2nd March 1931.	Do

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool .	(270) Mr. S P. Ranga Rao.	Barytes . .	P. L. .	200 21	29th January 1931.	1 year.
Do. .	(271) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	13·31	13th March 1931.	Do.
Do. .	(272) Do. .	Do. . .	P. L. .	1·50	18th June 1931.	Do.
Do. .	(273) Do. .	Do. . .	P. L. .	10·40	9th March 1931.	Do.
Do. .	(274) Khan Sahib Abdul Hye.	Do. . .	P. L. .	25 00	9th January 1931.	Do.
Do. .	(275) Do. .	Do. . .	P. L. .	48·32	Do. .	Do.
Do. .	(276) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	57·00	13th May 1931.	Do.
Do. .	(277) Mr. S. Jayarama Reddi.	Do. . .	P. L. .	2·00	12th August 1931.	Do.
Do. .	(278) Mr. G. Chinna Aswatham Setti.	Do. . .	P. L. .	4·80	23rd April 1931.	Do.
Do. .	(279) Mr. V. V. Subbayya Pantulu.	Do. . .	P. L. .	13·29	20th June 1931.	Do.
Do. .	(280) Mr. G. Singarayya Chetti.	Do. . .	P. L. .	2·00	31st July 1931.	Do.
Do. .	(281) Mr. G. Chinna Aswartham Chetti.	Do. . .	P. L. .	3·75	3rd August 1931.	Do.
Do. .	(282) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	33·50	25th June 1931.	Do.
Do. .	(283) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	5·40	13th May 1931.	Do.
Do. .	(284) Mr. S. Jayarama Reddi.	Do. . .	P. L. .	6·30	10th September 1931.	Do.
Do. .	(285) H. M. D. B. Abdul Nabi Sahib.	Do. . .	P. L. .	10·92	27th February 1931.	Do.
Do. .	(286) Mr. G. Singarayya Chetti.	Do. . .	P. L. .	10·40	18th August 1931.	Do.
Do. .	(287) H. M. D. Ashroff Hussain Khan Mandozie.	Do. . .	P. L. .	26·70	18th June 1931.	Do.
Do. .	(288) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	4·00	10th June 1931.	Do.
Do. .	(289) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	8·95	30th April 1931.	Do.
Do. .	(290) Mr. G. Chinna Aswartham Chetti.	Do. . .	P. L. .	5·50	27th June 1931.	Do.
Do. .	(291) H. M. D. Ashroff Hussain Khan Mandozie.	Do. . .	P. L. .	15·71	1st May 1931	Do
Do. .	(292) Do. .	Do. . .	P. L. .	12·00	18th June 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool .	(293) Mr. V. V. Subbayya Pantulu.	Barytes . .	P. L. .	72·00	23rd July 1931.	1 year.
Do. .	(294) Mr. S. Jayarama Reddi.	Do. . .	P. L. .	25·00	12th August 1931.	Do.
Do. .	(295) Mr. V. V. Subbayya Pantulu.	Do. . .	P. L. .	4·00	30th November 1930.	Do.
Do. .	(296) H. M. D. B. Abdul Nabi Sahib.	Do. . .	P. L. .	45·20	22nd April 1931.	Do.
Do. .	(297 Mr. V. V. Subbayya Pantulu.	Do. . .	P. L. .	10·00	23rd July 1931.	Do.
Do. .	(298) Mr. G. Chinna Aswartham Chetti.	Do. . .	P. L. .	69·00	4th August 1931.	Do.
Do. .	(299) H. M. D B. Abdul Nabi Sahib.	Do. . .	P. L. .	47·72	22nd April 1931.	Do.
Do. .	(300) Khan Sahib K. A. Hye Sahib.	Do. . .	P. L. .	12·95	23rd July 1931.	Do.
Do. .	(301) Do. .	Do. . .	P. L .	64·00	15th October 1931.	Do.
Do. .	(302) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	7·50	26th June 1931.	Do.
Do. .	(303) H. M. D. Ashroff Hussain Khan Mandozie.	Do. . .	P. L. .	21·20	4th May 1931.	Do.
Do. .	(304) Mr. G. Chinna Aswartham Chetti.	Do. .	P. L. .	20·00	25th June 1931.	Do.
Do. .	(305) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	12·40	26th October 1931.	Do.
Do. .	(306) Khan Sahib K. A. Hya Sahib and C. Manavalan.	Lead ore . .	P. L. .	16·93	20th August 1931.	Do.
Do. .	(307) Mr. B. P. Sesha Reddi.	Barytes . .	P. L. .	2·81	18th June 1931.	Do.
Do. .	(308) Do. .	Do. . .	P. L. .	4·59	18th June 1931.	Do.
Do. .	(309) Mr. G. Chinna Aswartham Chetti.	Do. . .	P. L. .	13·60	7th August 1931.	Do.
Do. .	(310) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	36·98	20th June 1931.	Do.
Do. .	(311) H. M. D. Ashroff Hussain Khan Mandozie.	Do. . .	P. L. .	23·07	1st July 1931.	Do.
Do. .	(312) H. M. D. B. Abdul Nab Sahib.	Do. . .	P. L. .	20·40	21st September 1931.	Do.
Do. .	(313) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	3·47	17th November 1931.	Do.
Do. .	(314) Mr. G. Singarayya Chetti.	Do. . .	P. L. .	1·00	7th December 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool .	(315) Mr. G. Singarayya Chetti.	Barytes . .	P. L. .	1·20	7th December 1931.	1 year.
Do. .	(316) Mr. S. P. Ranga Rao.	Asbestos . .	P. L. .	30·70	6th November 1931.	Do.
Do. .	(317) H. M. D. B Abdul Nabi Sahib.	Barytes . .	P. L. .	17·41	14th October 1931.	Do.
Do. .	(318) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	24·00	17th November 1931.	Do.
Do. .	(319) Mr. S. P. Ranga Rao.	Do. . .	P. L. .	19·50	9th December 1931.	Do.
Do. .	(320) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	30·00	22nd December 1931.	Do.
Do. .	(321) Do. .	Do. . .	P. L. .	22·00	22nd October 1931.	Do.
Do. .	(322) Do. .	Do. . .	P. L. .	25·60	10th December 1931.	Do.
Do. .	(323) Mr. M. Rajagopala Nayudu.	Do. . .	P. L. .	5·00	10th November 1931.	Do.
Do. .	(324) Mr. B. P. Sesha Reddi.	Do. . .	P. L. .	0·60	16th December 1931.	Do.
Do. .	(325) Mr. S P Ranga Rao.	Do. . .	P. L. .	8·00	28th November 1931.	Do.
Do. .	(326) Do. .	Do. . .	P. L. .	7·60	Do. .	Do.
Do. .	(327) Do. .	Do. .	P. L. .	23·00	15th December 1931.	Do.
Nellore .	(328) Mr. P. Venkatanarapa Reddi.	Mica . . .	M. L. .	7·55	11th October 1930.	30 years.
Do. .	(329) Mr. P. V. Subba Nayudu.	Do. . . .	M. L. .	7·56	21st January 1931.	Up to 5th December 1957.
Do. .	(330) Mr. P. Venkayya	Do. . . .	P. L. .	18·14	22nd June 1931.	1 year.
Do. .	(331) Mr. P. V. Subba Reddi.	Do. . . .	M. L. .	35·10	28th September 1930.	30 years.
Do. .	(332) Mr. G. Chenchu Subba Reddi.	Do. . . .	P. L. .	1·99	2nd May 1931	1 year.
Do. .	(333) Mr. P. V. Subba Reddi.	Do. . . .	M. L. .	2·62	23rd October 1931.	Up to 31st May 1958.
Do. .	(334) Mr. T. C. Dandayutham.	Do. . . .	P. L. .	14·59	26th September 1931.	1 year.
Do. .	(335) Mr. K. Gurumurthi Sastri.	Do. . . .	P. L. .	31·75	20th May 1931	Do.
Do. .	(336) Mr. K. Balarami Reddi.	Do. . . .	P. L. .	41·53	31st March 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(337) Mr. M. Venkata-Krishnayya.	Mica	M. L. .	72·18	17th September 1931.	30 years.
Do. .	(338) Mr. K. Balaram Reddi.	Do.	M. L. .	6·40	27th June 1931.	Do.
Do. .	(339) Mr. P. Venkayya	Do.	P. L. .	52·10	11th June 1931.	1 year.
Do. .	(340) Do. .	Do.	P. L. .	68·55	27th August 1931.	Do.
Do. .	(341) Mr. B. Dharma Nayudu.	Do.	P. L. .	7·10	13th September 1931.	Do.
North Arcot	(342) Mr. T. Athimoola Mudaliyar.	Do.	P. L. .	0·50	1st March 1931.	Do.
Salem .	(343) Mr. M. Edmond Gandart.	Magnesite . .	P. L. .	702·23	6th November 1931.	Do.

NORTH-WEST FRONTIER PROVINCE.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bannu .	(344) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. (renewal) .	8,723·2	3rd February 1931.	1 year.
Do. .	(345) Do. .	Do. .	P. L. (renewal). .	3,040·0	4th August 1931.	Do.
Do. .	(346) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. (renewal). .	13,245·0	2nd September 1931.	Do.
Dera Ismail Khan.	(347) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral Oil . .	P. L. (renewal). .	2,995·2	10th September 1931.	Do.
Do. .	(348) Do. .	Natural petroleum (including natural gas).	P. L. (renewal). .	1,321·6	10th March 1931.	Do.
Do. .	(349) Messrs. The Attock Oil Co., Ltd.	Mineral Oil . .	P. L. (renewal). .	150·0	26th November 1931.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

PUNJAB.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mianwali .	(350) Mr. Lala Doulat Ram.	Coal . . .	P. L. .	55·0	9th May 1931.	1 year.
Do. .	(351) Mr. Lala Chooni Lal Kapur.	Do. . . .	P. L.	133·0	11th November 1931.	Do.

P. L.=*Prospecting License.* M. L.—*Mining Lease.*

SUMMARY.

Province.	Prospecting License.	Mining Lease.	Quarry Lease.	Total of each Province.
Ajmer-Merwara	13	1	..	14
Assam	16	2	..	18
Baluchistan	(*a*) 2	..	..	2
Bengal.	1	..	..	1
Bihar and Orissa	6	13	..	19
Bombay	3	..	..	3
Burma.	103	17	..	120
Central Provinces	28	23	16	67
Madras	91	8	..	99
N.-W. F. Province	6	..	..	6
Punjab	2	..	..	2
Total of each kind and grand total	271	64	16	351
Total for 1930 .	334	64	16	414

(*a*) Includes one Exploring License.

Classification of Licenses and Leases.

TABLE 46.—*Prospecting Licenses and Mining Lease granted in Ajmer-Merwara during the year 1931.*

District.	1931. No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Ajmer	1	3·0	Kyanite.
Do.	4	12·9	Mica.
Do.	1	4·2	Kaolin.
Do.	1	4·5	Kaolin, mica, felspar, greenstone, muscovite or mica powder, garnet and beryl ore.
Beawar	1	3·5	Soapstone.
Do.	2	17·5	Asbestos.
Do.	1	18·9	Ochre and soapstone.
Do.	1	3·6	Asbestos and soapstone.
Do.	1	11·7	Graphite.
TOTAL	13	..	
	MINING LEASE.		
Ajmer	1	..	Beryl ore and precious stone.

TABLE 47.—*Prospecting Licenses and Mining Leases granted in Assam during the year 1931.*

District.	1931. No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Cachar	5	13,708·8	Mineral oil.
Lakhimpur	5	21,337·6	Do.
Do.	1	1,190·4	Coal.
Sibsagar	1	50·0	Do.
Sylhet	4	24,787·2	Mineral oil.
TOTAL	16	..	

TABLE 47.—*Prospecting Licenses and Mining Leases granted in Assam during the year 1931*— contd.

District.	1931.		
	No.	Area in acres.	Mineral.
	MINING LEASES.		
Khasi and Jaintia Hills .	1	2,348·8	Mineral oil.
Lakhimpur	1	2,560·0	Coal.
TOTAL .	2	..	

TABLE 48.—*Prospecting and Exploring Licenses granted in Baluchistan during the year 1931.*

District.	1931.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSE.		
Quetta Pishin	1	3,200·0	Coal.
	EXPLORING LICENSE.		
Sibi	1	491,520·0	Natural petroleum.

TABLE 49.—*Prospecting License granted in Bengal during the year 1931.*

District.	1931.		
	No.	Area in acres.	Mineral.
Chittagong	1	4,000·0	Natural petroleum.

TABLE 50.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during the year 1931.*

DISTRICT.	1931. No.	1931. Area in acres.	1931. Mineral.
PROSPECTING LICENSES.			
Angul	1	637·8	Ochre.
Hazaribagh	1	51·2	Sillimanite and kyanite.
Palamau	1	27·1	Graphite.
Singhbhum	2	1,936·3	Chromite.
Do.	1	548·0	All minerals except iron-ore, mica and precious stones.
TOTAL	6	..	
MINING LEASES.			
Hazaribagh	1	14·1	Garnet.
Santal Parganas	11	36·9	Coal.
Singhbhum	1	75·2	Iron-ore and manganese.
TOTAL	13	..	

TABLE 51.—*Prospecting Licenses granted in the Bombay Presidency during the year 1931.*

DISTRICT.	1931. No.	1931. Area in acres.	1931. Mineral.
PROSPECTING LICENSES.			
Kanara	1	223·0	Manganese ore.
Do.	1	38·8	Asbestos and talc.
Ratnagiri	1	1,280·0	Chromite.
TOTAL	3	..	

TABLE 52.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1931.*

District.	1931. No.	1931. Area in acres.	1931. Mineral.
	PROSPECTING LICENSES.		
Akyab	7	22,419·2	Natural petroleum (including natural gas).
Amherst	1	1,280·0	All minerals except oil.
Bhamo	3	7,385·6	Gold.
Lower Chindwin	3	7,225·6	Natural petroleum (including natural gas).
Magwe	11	33,217·7	Ditto.
Mergui	20	5,408·0	Tin and allied minerals.
Do.	12	2,457·6	Tin.
Do.	2	659·2	Gold, tin and allied minerals.
Do.	3	761·6	Tin and wolfram.
Do.	1	403·2	All minerals except oil and precious stones.
Do.	1	1,900·8	Tin and allied minerals except mineral oil.
Myingyan	2	2,080·0	Natural petroleum (including natural gas).
Northern Shan States	1	320·0	Lead ore and silver ore.
Pakokku	1	320·0	Natural petroleum (including natural gas).
Shwebo	1	5,440·0	Do.
Southern Shan States	3	2,080·0	All minerals except mineral oil.
Do.	1	960·0	Wolfram.
Tavoy	18	8,761·6	Tin and wolfram.
Thaton	1	403·2	All minerals except oil.
Thayetmyo	4	15,219·5	Natural petroleum (including natural gas).
Upper Chindwin	5	5,366·4	Coal.
Do.	2	8,960·0	Natural petroleum (including natural gas).
TOTAL	103	..	
	MINING LEASES.		
Mergui	1	230·4	Tin.
Do.	1	972·8	Tin and allied minerals.
Northern Shan States	3	122·8	Iron ore.
Pakokku	6	6,790·4	Natural petroleum (including natural gas).
Tavoy	1	1·9	Tin.
Do.	1	416·0	Tin and wolfram.
Do.	2	371·2	All minerals except oil and precious stones.
Do.	2	1,849·6	All minerals except oil.
TOTAL	17	..	

TABLE 53.—*Prospecting Licenses, Mining and Quarry Leases granted in the Central Provinces during the year 1931.*

District.	1931. No.	1931. Area in acres.	1931. Mineral.
PROSPECTING LICENSES.			
Balaghat	2	61	Manganese.
Bilaspur	1	95	Limestone and dolomite.
Do.	2	97	Limestone.
Chanda	1	3,840	Coal.
Chhindwara	2	289	Manganese.
Do.	10	8,075	Coal.
Jubbulpore	1	520	Platinum, silver, gold and vanadium.
Do.	3	558	Bauxite, chromium, copper, gold, silver, iridium, osmium, etc.
Do.	1	13	Yellow and red ochre.
Do.	1	67,130	Bauxite, gold, nickel, manganese platinum, silver and copper.
Do.	1	47	Limestone.
Do.	1	32	White clay.
Nagpur	1	105	Galena.
Raipur	1	169	Flagstone.
TOTAL	28	..	
MINING LEASES.			
Balaghat	2	34	Manganese.
Bhandara	1	30	Red iron oxide and bauxite.
Do.	1	20	Manganese.
Chhindwara	1	16	Do.
Do.	1	110	Coal.
Nagpur	17	864	Manganese.
TOTAL	23	..	
QUARRY LEASES.			
Bilaspur	3	68	Limestone.
Jubbulpore	1	24	Clay.
Do.	1	1	Laterite.
Do.	2	4	Limestone.
Nagpur	6	14	Clay.
Do.	1	2	Limestone.
Raipur	2	41	Flagstone.
TOTAL	16	..	

TABLE 54.—*Prospecting Licenses and Mining Leases granted in the Madras Presidency during the year 1931.*

DISTRICT.	1931. No.	1931. Area in acres.	1931. Mineral.
PROSPECTING LICENSES.			
Anantapur	2	72·35	Barytes.
Cuddapah	9	475·69	Do.
Do.	2	311·20	Do.
Kurnool	66	1,773·99	Do.
Do.	1	16·93	Lead ore.
Do.	1	30·70	Asbestos.
Nellore	8	256·35	Mica.
North Arcot	1	9·50	Do.
Salem	1	702·23	Magnesite.
TOTAL .	91	..	
MINING LEASES.			
Anantapur	1	131·50	Barytes.
Kurnool	1	10·00	Do.
Nellore	6	131·41	Mica.
TOTAL .	8	..	

TABLE 55.—*Prospecting Licenses granted in the North-West Frontier Province during the year 1931.*

DISTRICT.	1931. No.	1931. Area in acres.	1931. Mineral.
Bannu	3	25,011·2	Natural petroleum (including natural gas).
Dera Ismail Khan . .	3	4,466·8	Do.
TOTAL .	6	..	

Table 56.—*Prospecting Licenses granted in the Punjab during the year 1931.*

District	1931.		
	No.	Area in acres	Mineral
Mianwali	2	188·0	Coal.

MICROSCOPIC STUDY OF SOME INDIAN COALS. BY A. K. BANERJI, B.A. (CAL.), A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 11 to 14).

INTRODUCTION.

Microscopical examination of coal has now been for some years an established branch of study both in Europe and America and it is being very slowly recognised as an useful adjunct to the study of a coal seam. The work of Miss M. M. Evans[1] in England and of Dr. R. Thiessen[2] and his co-workers in America indicates that this method of study, when fully developed, is likely to offer a new means of correlating coal seams. There can, therefore, be little doubt as to its importance; the results so far obtained, however, are more of palæo-botanical than of economic interest. The materials that go to the making of a coal seam are all derived from the plant world and this method of study furnishes us with a means of identifying the different plant materials present in coal and of stating which element is predominant. It is now generally accepted that the nature of a coal is more or less related to the different plant elements that contributed to its formation and it may be possible to correlate the properties of a coal to definite plant elements present in it. The present conception as to the origin of two out of the three visible constituents of coal, namely, vitrain and fusain, are based on this method of study and it may lead to the elucidation of the conditions under which a particular coal seam was formed. The metallurgical microscope has also been put in commission in the study of coals and it offers a ready means of detecting the presence of finely disseminated pyrites in a sample, as well as of obtaining a fair idea of the amount of inorganic material that is not in a state of colloidal suspension.

[1] 'Correlation of the Parkgate Seam: A Preliminary Study', *Trans. Inst. Min. Eng.*, 71, p. 451, (1926).

[2] Thiessen, R. and Stand, J. N., 'Correlation of coal beds in the Monongahela Formation in Ohio, Pennsylvania and W. Virginia', *Carnegie Inst. Tech.*, Bull. 9, (1923); Thiessen, R. and Wilson, F. E., 'Correlation of coal beds in the Alleghany Formation of Western Pennsylvania and E. Ohio', *op. cit.* Bull. 10, (1924).

The aim of publishing this rather preliminary study of a few specimens is to direct attention to the possibility of throwing some light by this method of study on the problems connected with Indian Gondwana coals. A special feature of these coals is the persistent high ash content—the average being 11 to 12 per cent.[1]—as compared with coals from European countries. This has never been satisfactorily explained and is probably, in some cases, due to the allochthonous origin of the coals. Much valuable information may be obtained by studying whether the inorganic materials in the coals occur as sediments or in colloidal suspension.

Previous work.

Very little work on these lines has been done on Indian coals; the only work known to the author is that published by Mr. G. S. Caldwell.[2] In his paper, Mr. Caldwell appends a note by Mr. J. Lomax on the microscopical examination of ball coal from the bottom seam in Victoria colliery, Raniganj coalfield; the seam belongs to the Barakar series. As in the case of the two samples of Gondwana coal described in this paper, Mr. Lomax's examination showed a complete absence of megaspores in the coal. Microscopical investigations of coal of Gondwana age have also been published by Senor Domingos Fleury da Rocha[3] and by Dr. David White.[4] In the monograph by the former author, coals from the Urusunga am of Santa Catharina of Gondwana age are described and the presence of megaspores has been noted in the specimens examined. Dr David White records the occurrence of *Reinschia* (page 106 *et seq.*) in Brazilian coal and is of opinion that it is widely distributed there.

Place of study.

The author, while on leave in Germany during 1929, was able, through the courtesy of Dr. P. Krusch, President of the Prussian Geological Survey, to take up the study of some Indian coals. Samples had to be procured in a hurry by post, which accounts for the limited number of specimens studied. The investigation was carried out in the 'Institut für Palæobotanik und Petrographie der Brennsteine' of the Prussian Geological Survey in Berlin and the author is especially indebted to

[1] The average from 64 analyses published in Prof. Dunstan's paper on composition of Indian Coals in *Rec. Geol. Surv. Ind.*, XXXIII, p. 241, (1906) comes to 11·68 per cent.

[2] 'Notes on Indian Mining or experiences at an Indian Colliery', *Trans. Inst. Min. Met.*, LXXIV, p. 59, (1927).

[3] Monographia N. V. Servico Geologico et Mineralogico do Brasil, (1927).

[4] Relatorio Final Commissaa de Est. das Minoe de Carvas de Pedra do Brasil, Pt. III—Fossil Plants, p. 338.

Professor W. Gothan, under whose guidance the work was carried out, and to Dr. Hans Bode, for introducing him to the technique of coal petrography.

Method of study.

The microscopical study of coal falls under the following three heads :—

1. Examination of thin sections by transmitted light.
2. Examination of polished sections by reflected light using a metallographic microscope.
3. Examination of maceration products.

The usual method of making rock sections has to be modified in the case of coal, as a greater thinness is required in most cases.

Preparation of thin sections.

Sections were prepared by the methods described by Dr. R. Potonie[1] and that used by Mr. J. Lomax.[2] A method devised by Mr. C. Y. Hsieh, who had been working in the same laboratory on Chinese coals, of accomplishing the final thinning by means of rubbing with a piece of cork and dry 200-minute flour emery, gave good results.

The polished sections were prepared according to the method used by Prof. Schneiderhöhn[3] for examination of ore minerals. The

Preparation of polished sections.

polishing was done on a small horizontal revolving disc driven by a motor and covered with billiard-table cloth: the polishing media used was 'Tonerde' or aluminium oxide of two grades, Nos. 1 and 2, thinly suspended in water. In the case of fusain, very good results are obtained by previous 'cooking' in a solution of 'glass hard' canada balsam in benzol, over a water-bath, till the balsam solution becomes pasty; this is followed by drying of the sample a little below 100°C. This treatment also gives less trouble with brittle coal in the preparation of both thin and polished sections.

Preparation of maceration products is a palæo-botanical method of study applied to coal. The principle of the method is to dissolve

Maceration of coal.

out the more easily soluble constituents of coal by treatment with a strong oxidising agent; in the process, the more resistant parts of the plant debris

[1] 'Einführung in die allgemeine Kohlenpetrographie', p. 110.
[2] 'The Preparation and Examination of Coal Sections', *Jour. Roy. Micro. Soc.*, Sept. 1927, p. 239.
[3] 'Anleitung zur mikroskopischen Bestimmung und Untersuchung von Erzen im auffallenden Licht', pp. 52 *et seq.*, (1922).

are bleached, and can then be separated and studied. The different processes will be found described by Dr. Erich Stach.[1] In the present investigation Schulz's mixture was used.

Unfortunately, there is a certain lack of uniformity and some confusion as regards terminology in coal research. In the present paper, Dr. H. Bode's[2] modification of Dr. M. Stopes'[3] classification of the constituents of coal has been followed, clarain being considered an intimate and fine, *lit-par-lit* mixture of vitrain and durain. In the specimens examined there is no constituent that may not be designated either vitrain, durain or fusain and must be given another name, *viz.*, clarain. Dr. Fermor also failed to identify clarain in Bokaro coals.[4]

Terminology.

The chief microscopic characters by which the three constituents, vitrain, durain and fusain, have been judged may be briefly stated here.

Vitrain has a homogeneous appearance under the microscope and may or may not show vegetable structure; it never has any inclusion of visible detrital mineral matter nor of spores, pollen grains, cuticles or other vegetable debris except perhaps resin bodies.

Durain, under the microscope, shows a ground-mass of humic substance exhibiting no structure and in it are found embedded the more resistant elements of vegetable debris in small fragments, *viz.*, spores, exines, cuticles, pollen grains, particles of resin bodies and detrital mineral matter.

Fusain can never be made transparent and has a porous or cellular structure; it has been observed to be impregnated with crystalline mineral matter in patches, but rarely with the humic substance which forms the ground-mass of durain. Detrital mineral matter is entirely absent.

It is necessary to emphasise that the above-mentioned three constituents of coal refer only to bituminous coals. This differentiation into the three constituents named does not apply to the cases of anthracite and brown coal.

[1] 'Kohlenpetrographisches Praktikum', pp. 16-23.

[2] 'Zur Nomenklatur in der Kohlenpetrographie. Kohle u Erz', 18, pp. 699-710, (1928); 24, pp. 929-930, (1928).

[3] 'On the four visible ingredients in banded bituminous coal', *Proc. Roy. Soc.*, Ser. B, Vol. XC, p. 470 ff., (1919).

[4] *Rec. Geol. Surv. Ind.*, LX, p. 337, (1928).

The material examined comes from the following localities:—

Specimen No. 1.—Gondwana coal, Raniganj series (Upper Permian). From Bharungia, Jharia coalfield, Bihar and Orissa.

Specimen No. 2.—Gondwana coal, Karharbari stage (Lower Permian). From Giridih, Bihar and Orissa.

Specimen No. 3.—Lower to Middle Eocene coal. From Mach, Baluchistan.

Specimen No. 4.—Oligocene to Upper Eocene coal. From Kalewa (Chindwin), Burma.

SPECIMEN NO. 1.

This is a banded coal, the vitrain bands ranging up to 7 mm. The coal is very brittle, easily splitting along the vitrain layers; the vitrain exhibits its characteristic feature, breaking into cube-like segments. Two cleats at right angles to each other are well developed.

Macroscopic character.

The vitrain is madder-brown in colour showing no vegetable structure. Detrital mineral matter is entirely absent.

Vertical thin section.

The durain consists of a rather dark brown, humic ground-mass, which is difficult to render transparent. In the ground-mass are embedded numerous fragments of cuticles and microspores. There also occur some roughly lenticular patches of a bright reddish brown colour (Plate 11, fig. 1), which in vertical sections have the appearance of being made up of an aggregate of microspores. There is no indication of a capsule and they have been presumed to be clusters of microspores representing sporangia, the walls of the sporangia having been destroyed. These bodies are flattened along the bedding plane. No megaspores have been observed but a fair amount of detrital mineral matter is present, the grains being extremely angular. They show up very well when the nicols are crossed. The durain is also traversed by numerous, short, thin bands of vitrain. Lenses of fusain are common

The vitrain can be made transparent more easily in a horizontal section; no vegetable structure can be made out. In the durain, it is difficult to make out the vegetable debris as it seems to merge into the ground-mass, but the included mineral matter can be easily recognised under crossed nicols. The fusain does not present any peculiar feature.

Horizontal thin section.

Vertical polished section.

The vitrain bands, one of which is 5 mm. in thickness, do not show any structure.

The durain (Plate 11, fig. 2), is seen to be made up mostly of finely broken up fragments of cuticle, microspores being difficult to detect as the trace of the central cavity does not show up well. The thin section, however, has shown that microspores are present. As in thin section, megaspores are entirely absent. Fragments of fusain are frequent and there is a fair amount of detrital mineral matter.

In vertical section the fusain does not show any well-preserved internal wood structure.

Horizontal polished section.

The polished specimen examined was previously cooked in canada balsam and this previous treatment brings out the wood structure in fusain more clearly. In the laboratory of the Prussian Geological Survey, a solution of 'glass hard' canada balsam in benzol is used. The cooking was done in a porcelain dish; the dish with the coal in the solution was first put under the air pump (a filter pump may be used) to remove all the air from the pores in the coal. The dish was then heated on a water bath till all the benzol had been driven out and a soft pasty residue of canada balsam remained behind. The piece of coal was then taken out and dried over a water bath on a glass plate till the balsam was quite hard.

For the most part, the fusain bands show 'bogen' structure (Plate 11, fig. 3) the cells being all crushed, but here and there portions have escaped crushing. One portion shows a beautifully preserved transverse section of wood in places impregnated with iron pyrites (Plate 11, fig. 4). The structure is illustrated with a higher magnification in Plate 11, fig. 5. Mostly, one does not observe any intercellular spaces, but the presence of wood rays is clearly indicated. Another portion of the fusain gives a tangential section showing the wood rays better (Plate 11, fig. 6). The latter are seen to be uniseriate and to consist of two to three rays in height. Here, the tangential section of the bordered pits is beautifully preserved; some parts show the pore cut centrally and other parts, not cut centrally, do not show it. The structure is perhaps clearer than in many preparations of recent plants on account of the contrast; only the middle lamella is not visible. Another section, also tangential, (Plate 12, fig. 1), exhibits a peculiar thickening of the horizontal walls of the tracheids.

There is no structure in the vitrain in the horizontal section and no detrital mineral matter has been observed. In the durain, the cuticular debris appears as small, black, flat pieces (Plate 12, fig. 2).

Examination of maceration product.

Long treatment with Schulze's reagent, extending over two weeks was necessary to yield satisfactory products. The treatment yielded numerous fragments of woody elements. These show tracheids with bordered pitting (Plate 12, figs. 3*a*, 3*b*); the pitting is sometimes uniseriate and sometimes pluriseriate. Both contiguous and distant pits have been observed and they are mostly elliptical with elliptical pores. In one instance, a fragment shows a radial section of a medullary ray; on the walls of the ray occur single pits, one in each field.

The single pits on the fields of the medullary rays are a striking feature; a more striking feature still is that, in these fragments of wood, the pitting is not wholly contiguous but that there also occur spots with more or less distant uniseriate pits. This manner of pitting, so far as is known to the author, has not been noticed in Indian fossil woods of Lower Gondwana age. Mr. Walton[1] has described and emphasised the separation of bordered pits in *Dadoxylon arberi*, Sew. from the Lower Beaufort series of South Africa and the same characteristic has also been found by Prof. Sahni[2] in *Dadoxylon arberi*, Sew. from the Newcastle series of New South Wales. In describing the species *Dadoxylon bakeri* from the Permo-Carboniferous of the Falkland Islands, Prof. Seward and Mr. Walton[3] state that the bordered pits on the tracheids succeeding the larger spring-elements are often uniseriate and distant. It appears therefore, that the separation of pits in Gondwana woods had already begun in Lower Gondwana time and is of interest for the whole story of the development of pitting in gymnospermous woods. This is not the appropriate place for discussing a purely botanical question but reference may be made to the paper of Prof. Gothan 'Uber die Wandlungen der Hoftupfelung bei den Gymnospermen in Laufe der geologischen Epochen und ihre physiologische Bedeutung.'[4]

[1] Walton, John, 'On some South African Fossil Woods', *Ann. S. Afr. Mus.*, Vol. XXI, p. 23, (1925).

[2] Sahni, B. and T. C. N. Singh, 'On some specimens of *Dadoxylon arberi*, Sew., *Journ. Ind. Bot. Soc.*, Vol. V, p. 107, (1926).

[3] Seward, A. C. and J. Walton, 'On a collection of fossil plants from the Falkland Islands', *Quart. Journ. Geol. Soc.*, Vol. LXXIX, p. 326, (1923).

[4] 'Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin', No. 2. (February, 1907).

Besides the woody fragments, there occur in the macerated product numerous bodies like microspores; they are found attached to each other in groups of twos or more, but solitary individuals are also seen and they possess rounded outlines. No markings on the surface of these can be definitely established. I have taken the bodies to be microspores.

Origin of the coal.

The examination of the coal has not brought forth any evidence indicating an allochthonous origin for the coal. Pronounced bands of vitrain alternating with durain and the preponderance of woody elements in the macerated product indicate that woody stems contributed largely to the formation of the coal. The durain shows that considerable vegetable debris, derived from the disintegration of cuticles, is present, together with spore-like bodies which have a habit of occurring in clusters. There seems to have been no agency at work sorting out the various products of vegetable growth. This seems to favour the hypothesis of an autochthonous origin for the coal. The amount of detrital mineral matter, however, is more or less high. This would indicate movement of water bringing in sediment, possibly periodic over-flooding of the area while the deposit was being formed.

SPECIMEN NO. 2.

Macroscopic character.

This is a matte coal with very thin bands of vitrain which do not exceed one mm. in individual thickness. This fine banding gives a dull lustre of satin-like effect to the coal. The fracture is hackly. One cleat perpendicular to the bedding is well developed, but the other at right angles to it is not very well pronounced. The specimen does not appreciably soil the fingers and appears to be poor in fusain. The coal is predominantly duritic.

Vertical thin section.

The ground-mass is extremely refractory and could not be made sufficiently transparent; the section can only be examined with the help of strong artificial light. It is traversed by long, fine, thread-like bands which have the reddish brown colour of vitrain (Plate 12, fig. 1). It is difficult to say from what kinds of plant elements these thread-like bands of vitrain originated. They cannot represent cuticles as they coalesce into broader bands and again diverge; also, in no parts is the characteristic yellow colour of cuticle observed. The only

explanation that can be suggested is that these fine bands represent cells or groups of cells of woody stems which have become vitrainised, the remaining portion of the wood having completely decayed into the dark, duritic ground-mass. Broader bands of vitrain also occur. No spores of any kind can be detected and owing to the opacity of the ground-mass it is difficult to differentiate fusain from the ground-mass.

Horizontal thin section.

The horizontal section represents mostly the duritic portion of the coal; where it has been rendered sufficiently thin, it appears as dark brown, irregular patches. Here and there may be seen what is undoubted wood structure merging into the opaque ground-mass. Indications of structure representing tracheids and wood rays can be made out. In some instances, structures resembling bordered pits are observed. All these evidently represent vitrainised portions of woody elements. As will be seen in the sequel, this coal, by treatment by the maceration process, has yielded mostly fragments of tracheids with bordered pits.

Vertical polished section.

The vitrain which, as already stated, is in thin lenticular bands under one mm. in thickness, shows cell structure. Where the cells have escaped crushing, a transverse section of wood is seen. The presence of annual rings in many Gondwana woods is well known, but I doubt if the uncrushed cell can be said to represent the thicker walled cells of summer wood which have escaped crushing owing to the thickness of their walls. They are lineally arranged parallel to the bedding plane and, traced laterally, they pass into crushed cells.

Bands of fussain show the characteristic 'bogen' structure.

The durain is characterised by the presence of elliptical, alveolated bodies (Plate 12, fig. 5), very similar to those found by Prof. Jeffrey and Mr. Chrysler[1] in the lignites of Brandon and named by them *Sclerotitis brandonianus*, which they determined as representing a sclerotium stage of some fungus. Similar bodies have also been observed by Dr. Bode in the Miocene 'Braunkohle' from the Niederrhein province, by Dr. Reicheubach[2] in some bituminous coals

[1] Jeffrey, E. C. and Chrysler, M. A., 'The Lignites of Brandon', *Report of the Vermont State Geologist*, 1905-1906, pp. 195-201.

[2] Reicheubach, R., 'Beitrage zur Kenntnis der Kohlen der Kolumbianischer Ost-kordillere', Mit. der Abt. fur Gest. Erz. Kohle—und Salz Untersuchungen, Heft 6, Preuss. Geol. Landalt., (1926).

from Columbia and by Dr. Horn[1] in specimens of Spitzbergen coal. Besides, some rounded spore-like bodies also appear, as in the case of Brandon lignites, which Prof. Jeffrey believes originated possibly from the disintegration of the alveolar masses (Plate 13, fig. 1). In the durain there also occur numerous angular and bow shaped fragments of debris which, in the polished section, have the appearance of vitrain; these seem to be derived from the disintegration of the sclerotium bodies. The durain is mainly composed of these sclerotium elements in a humic ground-mass, megaspores being completely absent and I have not been able to detect the presence of microspores. There is a fair amount of detrital mineral matter and fragments of fusain are common.

Horizontal polished section.

The fungus bodies come out more clearly in horizontal section; the section includes a patch or lens of vitrain with a cluster of these bodies lying on it (Plate 13, fig. 2). Evidently, it represents a fragment of wood which has been attacked by fungi. As in the other section, the durain is composed mostly of fragmentary parts of these fungus bodies; no spores can be made out.

The vitrain does not show any structure.

Examination of maceration product.

With this specimen also, a long treatment in Schulze's reagent extending over nearly two weeks was necessary before satisfactory results were obtained. The treatment yielded mostly fragments of wood which are seen to be tracheids with araucarian pitting. Both uniseriate and pluriseriate—mostly alternating biseriate—bordered pitting has been observed. The uniseriate pits are closely contiguous, approximate to hexagonal outline and have round 'pores'. The biseriate pits are alternate with both round and elliptical 'pores' and though fairly contiguous, preserve in some cases elliptical outlines (Plate 13, figs. 3*a*, 3*b*). In the absence of fragments showing radial sections of wood rays, it is not possible to determine these woods; it can only be said that they belong to the *Dadoxylon* type.

In the macerated product there is a complete absence of spores, pollen grains or cuticles. This fact is significant as it confirms the conclusion, arrived at from the examination of thin sections, that the coal was formed mostly from woody stems.

[1] 'Beitrage zur Kenntnis der Kohle Svalbard', Oslo, (1920).

Origin of the coal.

The examination of the sample has shown that the coal originated chiefly from woody stems, there being a complete absence of cuticles and spores. Yet the coal is predominantly duritic while one would expect it to be predominantly vitrainic. The wood has been extensively attacked by fungi, as indicated by the abundant fungi remains, and this probably has brought about the formation of durain, the wood thereby being easily decomposed. The vitrain occurs only in very thin bands representing the parts that escaped decomposition and attack by fungi. The absence of finer plant debris seems to indicate an allochthonous origin for the coal, the deposit being formed from logs transported by water. The presence of fungi shows that the logs were not submerged under water all the time and that the climatic conditions were moist.

SPECIMEN NO. 3.

Macroscopic character.

This coal is of homogeneous appearance with pitch-like lustre; the streak is decidedly dark brown and the coal is rather brittle, breaking with sub-conchoidal fracture. In water, the coal breaks up into fragments with a cracking noise. According to German classification it is 'Glanzbraunkohl' or what was formerly known as 'Pechkohl'.

Vertical thin section.

The section shows incipient banding, but there is no definite differentiation into durain and vitrain as is generally the case with brown coal. In one place, cellular wood structure is observed, otherwise, the presence of the various kinds of plant debris cannot be made out, as cuticular fragments and spores are not common. The fungus bodies observed in polished section are represented by dark brown, round bodies almost opaque and showing no structure.

Horizontal thin section.

In horizontal section, the coal appears more or less homogeneous, except for the dark opaque patches which represent fungus bodies In thin sections, iron pyrites is difficult to detect, though it comes out very conspicuously in polished sections of this coal.

The presence of pollen grains cannot be definitely established; maceration, however, shows them to be present.

Polished section.

Before polishing, the specimens were cooked in canada balsam, as the coal breaks up into small fragments when moistened with water or exposed to air for some time; this is known to be the case also in European 'Glanzbraunkohlen' of this rank.

The specimen has a very homogenous appearance, only small strips of cuticle appearing here and there (Plate 13, fig. 4). In the section there is a definite direction along which small fungus bodies are arranged lineally; they occur in a chain and the band very probably represents a stem of wood which had been attacked by fungi, (Plate 13, fig. 5). In Plate 13, fig. 6 is illustrated one of these *Sclerotitis sp.* on a higher magnification.

The whole coal is impregnated with small grains of iron pyrites, which impregnation, as already stated, is not seen in thin section. The presence of this finely disseminated pyrite may partly account for the breaking up of the coal into small fragments when placed in water. Very little detrital mineral matter has been observed.

Examination of maceration product.

The product obtained by maceration consists mostly of fragments of cuticles and microspores, some of the latter showing the characteristic marking due to tetrad grouping. Plate 14, fig. 1 illustrates a fragment of cuticle showing stomatic openings.

SPECIMEN NO. 4.

Macroscopic character.

This is a coal with pitch-like lustre showing no banding. It has a homogeneous appearance and splits easily along the bedding plane. The fracture is hackly and the streak dark brown. A portion when split along the bedding plane showed 'augen' structure.

Vertical thin section.

The ground-mass shows finely laminated structure due probably to finely broken up plant debris. Fragments of bright yellow cuticle are numerous, (Plate 14, fig. 2), as well as the fungus bodies, which are usually dark brown in colour; some are alveolar, others with a single central cavity are usually egg-shaped.

Horizontal thin section.

The horizontal section shows the presence of numerous pollen grains—both round and oval—and rizontal sections of cuticles with indefinite boundaries passing imperceptibly into the brown humic ground-mass. The presence of fungus bodies can also be made out.

Compared with the other Tertiary coal, this sample has a more laminated appearance and the occurrence of fragments of cuticle is more frequent. There is, however, no definite band of what may be called vitrain or durain. It also shows the frequent presence of fungus bodies arranged in definite bands as in the case of the other Tertiary coal, (Plate 14, fig. 3). Pyrite is sparingly present, but there is a certain amount of detrital mineral matter.

Polished section.

The maceration products for the most part consist of fragments of leaf cuticles. Two types of cuticles are present, one with small polygonal cells, (Plate 14, fig. 4), and the other with elongated rectangular cells, (Plate 14, fig. 5). Stomatic openings have been observed only in the latter. Besides the leaf cuticles there is present a certain amount of pollen grains. They are also of two types, one round and the other elliptical in shape. Plate 14, fig. 6 illustrates a cluster of the latter variety. The fungus bodies are represented by small, very dark brown, in some cases almost black, opaque globules.

Examination of maceration product.

CONCLUSIONS.

The examination of the two Gondwana coals has shown that woody stems contributed to some extent to the formation of the coals; they may, therefore, be said to have originated from tree-like plants. The presence of araucarian pitting has been definitely established, while no scalariform tracheids characteristic of the *Filicales* has been observed. This seems to indicate a gymnospermous affinity of a portion at least of the flora, especially as megaspores are completely absent.

Gondwana coals.

One of the most striking features of the Indian Tertiary coals is the relatively frequent occurrence of sclerotium bodies of certain fungi, partly differentiated into several cells and partly simple. It will be important to observe whether these bodies occur with the same frequency in other brown coals or lignites. They have been observed in the German brown coals from Niederrhein province and in the Tertiary coals of Spitzbergen[1] and Columbia.[2] Their presence cannot be

Tertiary coals.

[1] Horn, G., 'Beitrage zur Kenntnis der Kohle von Svalbard', Oslo, (1920).

[2] Reicheubach, R., 'Beitrage zur Kenntnis der Kohlen der Kolumbianischer Ostkordillere', Mit. du Abl. fur Gest. Erz. Kohle-und Salz Untersuchungen, Heft 6, Preuss. Geol. Landesanslalt, (1928).

taken to indicate a regional character, a special feature of tropical regions. They are, however, certainly more frequent in Tertiary coals than in the coals from the Palæozoic and Mesozoic.

LIST OF ILLUSTRATIONS.

SPECIMEN No. 1.

SPECIMEN No. 2.

SPECIMEN No. 3.

SPECIMEN No. 4.

PLATE 14, Fig. 2.—Thin section. Vertical, showing cuticle. ×100.
,, 14, ,, 3.—Vertical (?) polished section. *Sclerotitis* sp. ×228.
,, 14, ,, 4.—Fragment of cuticle obtained by maceration. ×100.
,, 14, ,, 5.—Fragment of cuticle obtained by maceration. ×100.
,, 14, ,, 6.—Pollen grains obtained by maceration. ×100.

THE SPECIFIC GRAVITY AND POROSITY OF INDIAN BUILDING STONES. BY G. DE P. COTTER, SC.D. (DUB.), F.G.S., M. INST. M.M., *Superintendent, Geological Survey of India.*

F. Becke [1] and R. A. Daly [2] have pointed out the importance of recording the specific gravities of rocks. It seemed therefore worthwhile to publish some results obtained many years ago on the specific gravity and porosity of Indian building stones.

When I first joined the Geological Survey of India in the year 1905, I was set to work at a collection of building stones, the specific gravities and porosities of which it was required to determine. Our laboratory was not in those days fitted with the appliances necessary for forcing water into the pores of the rock by creating a vacuum in the water container in which the rock was placed. The method adopted, after preliminary experiment, was to soak the specimens in water for five days, after which it was found that the increase in weight, due to the further absorption of water, was small enough to be neglected for practical purposes. Each specimen was first weighed in air, and again weighed in air after a five days' immersion in water, and finally weighed in water. The specific gravity was calculated in the ordinary way from the first and third weighings. The porosity was found by a comparison of the first and second weighings, which gave the amount of water absorbed in five days.

There are, it is admitted, inaccuracies in the method adopted, as, in the case of specimens with high porosity, the immersion for five days in water was probably not sufficient to drive out all the air from the interior of the specimens, some of which show, in consequence, too low a specific gravity.

The fact that there were no appliances for forcing the water into the pores by exhausting the air in the container, and the varying size of the building stones, prevented any more accurate determination.

The average size of the specimens was about five inches cube; in fact, they were rather too large for accurate work.

[1] F. Becke: Das spezifische Gewicht der Tiefengesteine. *Sitzungsber. d. Math. Naturwiss. Klassed. kais. Akad. d. Wiss. Wien*, Band CXX, Abt. 1, p. 265, (1911).
[2] R. A. Daly: Igneous Rocks and Their Origin, p. 38. (New York, 1914).

Nevertheless, the results are of some interest, and give a fair idea of the porosity and specific gravity of Indian building stones.

In the table subjoined, the first column gives the registered number of the specimens in the registers of the Geological Survey of India; the second column is the name of the rock; the third column shows the locality, while the fourth column gives the porosity expressed as the number of grammes of water absorbed by 1,000 grammes of rock. The fifth column shows the specific gravity.

I have felt rather doubtful about the usefulness of publishing results done on large stones of varying size, and without immersion in water *in vacuo*, but I have decided, rather than have this work buried in files, to offer it, such as it is, to the *Records of the Geological Survey of India.*[1]

Table showing the Specific Gravity and Porosity of certain Indian Building Stones.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/113	Grey granite, Bundelkhand gneiss series.	Quarry between Kalahasti and Renigunta.	1·408	2·641
17/114	Pink granite, Bundelkhand gneiss series.	Sivapuram quarry, a quarter of a mile from Sivapuram (15° 21′: 76° 25′).	0·570	2·652
17/115	Grey granite, Bundelkhand gneiss series.	*Do.* . . .	0·378	2·663
17/135	Scapolite-gneiss, Aravalli system.	Khalroda (28° 5′: 76° 7′).	0·556	2·946
17/136	Scapolite-gneiss, Aravalli system.	Mokhuto (27° 56′: 73° 59′).	0·749	2·823
17/137	*Do.* . . .	Goal-ka-Khalm, eight miles from Beawar.	2·622	2·900
17/187	Gneiss, Delhi system .	Madar, near Ajmir .	4·006	2·679

[1] The author is unduly modest concerning the value of this paper. The data presented are of much interest and their value is enhanced by the fact that the determinations were made on relatively large specimens—namely 5-inch cubes. The only results that may appear unusual are the values for the specific gravity of khondalite, which are much below the true values for fresh specimens. In certain calculations concerning the specific gravity of the Eastern Ghats province, I have taken 2·93 as the average specific gravity of khondalite, this figure being based on specimens collected by T. L. Walker and C. S. Middlemiss. Khondalites used for building purposes are almost always much weathered varieties. The low specific gravities shown in Dr. Cotter's table are a measure of the amount of alteration of the samples tested.—L. L. Fermor.

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—contd.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/760	Khondalite . . .	Khigerimudla, three miles south of Jatnee.	65·186	2·393
17/761	*Do.* . . .	Sangar, three miles from Kuluparaghat station.	10·637	2·453
17/762	*Do.* . . .	Quarry at Golabund, six miles from Berhampore.	55·546	2·188
17/763	*Do.* . . .	Quarry at Rajpur, five miles from Ichapuram.	79·296	2·494
17/764	*Do.* . . .	Sampeta quarry, 1½ miles from Sampeta station.	45·157	2·509
17/766	*Do.* . . .	Kilavada Kondu quarry, near Nellimarla.	37·982	2·362
17/768	Quartz-garnet-rock .	Penlu Padar quarry, 3½ miles from Palasa.	40·946	2·430
17/140	Quartz-schist . .	Seriti (27° 56′: 76° 4′ 30″).	0·271	2·660
17/141	*Do.* . . .	Saral Doongri (27° 56′: 76° 12′).	0·200	2·660
17/142	*Do.* . . .	Kalaoth, between Arnu and Bhan Khari, R. M. Ry.	1·074	2·652
17/143	*Do.* . . .	Between Bhan Khari and Dausa.	0·558	2·682
17/144	*Do.* . . .	Silora, Kishengarh, Rajputana.	3·365	2·672
17/145	*Do.* . . .	*Do.* . . .	3·312	2·688
17/146	*Do.* . . .	Srinagar, ten miles from Ajmir.	11·056	2·635
17/147	*Do.* . . .	Rasulpura, near Madar station, Rajputana.	1·196	2·665
17/148	*Do.* . . .	*Do.* . .	3·636	2·451
17/207	Basalt, Deccan trap .	Pindrai Mandla district (22° 31′: 80° 5′).	2·937	2·851
17/208	*Do.* . . .	Shikara, Seoni district (22° 47′: 79° 55′).	1·608	2·935
17/209	*Do.* . . .	Temu quarry, Kharpa, Jabalpur district (22° 51′:).	5·563	2·740
17/210	*Do.* . . .	Gournalla, Jamtara, Jabalpur district (23° 5′: 80° 2′).	1·671	2·899

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—contd.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/211	Basalt Decan trap .	Quarries near Barka, east of Runija station (25° 12': 75° 23').	1·391	2·957
17/212	*Do.* . . .	Deo Gotaria, Indore (20° 40': 75° 58').	0·780	2·919
17/213	*Do.* . . .	Paddhari (22° 26': 70° 37').	5·029	2·788
17/214	*Do.* . . .	Tharala, three miles west of Rajkot (22° 18': 70° 50').	5·269	2·892
17/216	Altered rhyolite . .	Rajula (21° 3': 71° 29')	9·091	2·553
17/218	*Do.* . . .	*Do.* . . .	8·416	2·579
17/220	*Do.* . . .	Raina quarry near Sehore (21° 43': 71° 59').	26·373	2·563
17/122	Crystalline limestone Arvalli system.	Kali Pahadi (28° 12': 73° 31').	0·024	2·717
17/123	*Do.* . . .	Antri (27° 56': 76° 8') .	0·458	2·874
17/124	*Do.* . .	Dhrota (28° 0' 30": 76° 5').	0·174	2·923
17/125	*Do.* . . .	Khairoda (28° 5': 76° 7')	0·155	2·912
17/126	*Do.* . . .	Jhilo (27° 51': 75° 57')	0·778	2·891
17/127	*Do.* . . .	Kharadi hill (27° 50': 75° 51').	0·000	2·742
17/127	*Do.* (second specimen).	*Do.* . .	0·000	2·749
17/128	*Do.* . . .	Chokdi (27° 39': 75° 40')	0·616	2·788
17/128	*Do.* (second specimen).	*Do.* . . .	1·047	2·746
17/129	*Do.* . . .	Bodheli (27° 41': 75° 48').	0·000	2·772
17/130	*Do.* . . .	*Do.* . . .	0·077	2·740
17/133	*Do.* . . .	Jamun-ki-Chauki, near Ajmir.	0·075	2·873
17/134	*Do.* . . .	Morthalla (27° 56': 75° 59').	0·190	2·792
17/152	Marble, Carboniferous .	Marble Isle, near Mergui, Lower Burma.	0·061	2·747
17/163	Shaly limestone, Lower Vindhyans of Raipur.	Paraghat, east of Bilaspur.	2·125	2·732
17/165	Black limestone, Lower Vindhyans of Raipur.	Sanipathar, 62 miles east of Bilaspur.	0·272	2·722

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—contd.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/180	Limestone, Lower Vindhyans	Nimbahera quarry .	0·122	2·723
17/181	*Do.*	Seona Kolwa (Sukhera) quarry seven miles from Neemach.	0·190	2·719
17/225A	Porebander stone, or aeolian limestone (Sub-Recent).	Shakar quarry, 2½ miles from Ranavar station (21° 42′ : 69° 47′).	186·831	2·323
17/226B	Porebander stone . .	Bhogara quarry, 1½ miles from Ranavar station.	202·722	2·453
17/227C	*Do.*	Gared quarry, two miles from Ranavar station.	171·037	2·240
17/228D	*Do.*	Barwas quarry, one mile from Chorwad station (21° 2′ : 70° 16′).	78·098	2·119
17/229E	*Do.* . .	Lowar quarry, near Barwas quarry.	58·861	2·233
17/230F	*Do.* . . .	White quarry, three miles from Chorwad station.	69·706	2·144
17/231G	*Do.* . .	Mohobatpura quarry, five miles from Chorwad station.	87·828	2·232
17/232H	*Do.*	Junagad quarry, three miles from Junagad station (21° 32′ : 70° 29′).	172·474	2,503
17/189	Calcareous sandstone, Damuda series.	Banali, near Raniganj, E. I. Ry.	26·039	2·610
17/190	*Do.*	Raniganj, E. I. Ry. .	18·370	2·031
17/197	*Do.*	Ramnayajar quarry, Ammoha, Karkeli.	40·053	2·553
17/199	Calcareous sandstone, Upper Gondwanas.	Panki quarry, four miles from Dhrangadra station.	53,967	2,498
17/204	Calcareous sandstone, Lameta beds.	Ghattia quarries, near Kanai (22° 20′ : 76° 12′).	93,071	2·528
17/205	*Do.*	*Do.*	45·556	2·526
1435 P. R. (A)	Foraminiferal limestone	Bagatora, Karachi district (26° 20′ : 67° 54′)	1·252	2·705
1435 P. R. (B)	*Do.* . .	Hans Hill quarry at Karachi (24° 52′ : 67° 7′).	34·052	2·529
1435 P. R. (C)	Foraminiferal sandy limestone.	Tandui quarry, Sibi district (29° 11′ : 67° 58′).	20·447	2·527

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—contd.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
1435 P. R. (D)	Foraminiferal sandy limestone.	Kalati Killa quarry, Sibi district (29° 14′ 40″: 61° 1′ 15″).	9·636	2·635
1435 P. R. (E)	Grey, chalky, fine-grained limestone.	Spintangi quarry, Sibi district (29° 55′: 68° 8′).	6·979	2·728
1435 P. R. (F)	Sandy limestone . .	Khost quarry, Khost district (30° 34′ 40″: 67° 37′).	19·426	2·666
1435 P. R. (G)	Grey, chalky, fine-grained limestone.	Drigi quarry, (30° 25′: 67° 31′).	0·949	2·701
1435 P. R. (H)	Foraminiferal limestone	Mangi quarry, Mangi (30° 22′ 40″: 67° 28′ 10″).	0·713	2·673
1435 P. R. (I)	Very calcareous sandstone.	Kachh quarry, Kachh, (30° 25′ 30″: 67° 20′ 50″).	45·948	2·558
1435 P. R. (J)	Sandy limestone . .	Bhagwanwala quarry, Jhelum district (32° 45′: 73° 0′).	18·566	2·661
1435 P. R. (K)	*Do.* . . .	Taraki quarry, Jhelum district (33° 1′: 73° 28′ 10″).	15·815	2·669
1435 P. R. (L)	Very calcareous sandstone.	Bawal quarry, 3½ miles west Taraki station (33° 0′: 73° 30′).	9·030	2·663
17/150	Sandstone (age unknown)	Dighwara station, R. M. Ry.	30·250	2·429
17/153	Sandstone, Lower Kaladgi.	Adegal, Badami taluq .	17·028	2·618
17/154	*Do.* . . .	*Do.* . . .	19·182	2·607
17/155	*Do.* . . .	*Do.* . . .	5·860	2·620
17/156	*Do.* . . .	*Do.* . . .	9·142	2·643
17/164	Sandstone, Lower Vindhyans.	Arpa river, east of Bilaspur.	18·853	2·712
17/166	Sandstone, Upper Vindhyans.	Agra, local quarry .	34·578	2·719
17/167	*Do.* . . .	Gharonti quarry, near Agra.	9·349	2·644
17/168	*Do.* . . .	Achnera quarry, near Agra.	13·987	2·496
17/169	Sandstone, Kaimur beds	Jubai quarry, Shiurajpur.	25·680	2·459
17/171	*Do.* . . .	*Do.* . . .	20·187	2·482
17/173	*Do.* . . .	Jugai quarry, Shiurajpur.	19·698	2·488

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—contd.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/175	Sandstone Kaimur beds .	Birohi quarry, Mirzapur.	24·613	2·586
17/184	Sandstone Upper Bhander beds.	Bharatpur . . .	31·972	2·513
17/185	*Do.* . .	Hindaun . . .	45·603	2·630
17/186	Sandstone Upper Vindhyans.	*Do.* . . .	39·708	2·555
17/191	Sandstone (non-calcareous).	Gheria stone No. 1, E. I. Ry.	18·179	2·551
17/192	Sandstone, Damuda series.	Gheria stone No. 2, E. I. Ry.	18·465	2·549
17/193	*Do.* . . .	Mulkhera stone, B. N. Ry.	19·994	2·543
17/194	*Do.* . . .	River bridge, near Jharsugoda.	45·211	2·610
17/195	*Do.* . . .	Anuppur, near Anarkantak.	37·747	2·401
17/196	*Do.*	Ramnayajar quarry, Ammoha, Karkeli.	48·885	2·386
17/198	Micaceous sandstone Damuda series.	Vikampur, near Burhar station.	51·575	2·576
17/201	Sandstone, Upper Gondwanas.	Isularia quarry, Dhrangadra station.	61·877	2·511
17/202	White, fine-grained sandstone, Upper Gondwana or Lameta.	Sya Nalla, Rampur, Jabalpur district (23° 9′ : 80° 0′).	31·680	2·535
17/203	Sandstone, Upper Gondwana or Lameta.	Quarry near Idar, Ahmednagar (23° 35′ : 73° 0′).	30·120	2·467
17/200	Sandstone, Lameta beds (non-calcareous).	Ghatila quarries, near Kanai (22° 20′ : 76° 12′).	52·066	2·472
17/755	Buff, porous grit . .	Naraj, seven miles north-west of Cuttack.	60·713	2·378
17/756	Cream sandstone, medium to fine-grained.	*Do.* . . .	33·602	2·390
17/757	Buff, coarse-grained sandstone.	Khundagiri, three miles west of Bhubaneswar.	50·452	2·377
17/758	Very fine-grained, cream, argillaceous sandstone.	*Do.* . . .	54·944	2·545
17/765	Sandstone . . .	Jabidy Mitta quarry, near Kothu Bhema Singhi.	45·083	2·408
17/767	Ferruginous sandstone .	Padepadra quarry, 1½ miles from Chatrapur station.	45·094	3·252

Table showing the Specific Gravity and Porosity of certain Indian Building Stones—concld.

Number in Rock Register.	Description.	Locality.	Porosity, as grammes of water per 1,000 grammes of rock.	Specific gravity.
17/772	Non-calcareous sandstone.	Bharol quarry, seven miles east of Malakhera (27° 20′: 76° 35′).	21·271	2·409
17/778	*Do.* . . .	Bilurdi quarry, near Bharol quarry (see last entry).	25·885	2·367
17/138	Roofing slate . .	Manathi Parla, near Koond, (28° 9′: 76° 27′).	13·117	2·754
17/160	Basal conglomerate, Lower Vindhyans.	Kota, north of Bilaspur	2·764	2·648
17/162	Hornstone, Lower Vindhyans.	Parsada, east of Bilaspur	1·261	2·634
17,222	Laterite . . .	Khargpur district . .	69·946	2·739
17/223	*Do.* . . .	*Do.* . . .	53·128	2·634
17/224	*Do.* . .	*Do.* . .	36·302	2·650
17/769	*Do* . . .	Jatnee Khurd Road .	51·856	2·581
17/770	*Do* . . .	Bhomitika two miles east of Jatree	65·610	2·530
17/771	*Do.* . .	Between Kuhm and Khurda	61·95	2·556

A STUDY OF THE INDIAN SEISMOLOGICAL RECORDS OF THE CHIEF SHOCKS WHICH OCCURRED IN THE NORTH-EAST FRONTIER REGION OF BURMA DURING 1929-1930.

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CONTENTS.

I.—INTRODUCTION

Limitation of paper.

During the past few years, the North-East Frontier Region of Burma has been the scene of very considerable seismic activity. A detailed account of these earthquakes will shortly be published by my colleague, Dr. H. L. Chhibber. The present paper is confined to a study of such seismological records of the major shocks as were available from Indian observatories.

Epicentre.

The epicentre of these shocks has been taken as the Lagwi pass on the frontier between the Myitkyina district and Yunnan. Its determination is due to the field observations of Dr. Chhibber during two visits to this area in the latter parts of the years 1929 and 1930. The shocks

are caused by movement along a fault plane between the granite and volcanic tuffs which meet at the Lagwi pass.

Seismological records of certain major shocks which occurred during 1929 and 1930 were received from the following observatories:—Alipore, Colaba and Kodaikanal. Records were also received from the Director, Geodetic Branch, Survey of India, at Dehra Dun.

Observatories.

I am greatly indebted to my colleague, Mr. P. Leicester, for the calculation of the great circle distances from the epicentre to the above observatories by the solution of the spherical triangles and subsequent conversion of sea miles to statute miles, utilising the latitude and longitude of the epicentre and each observatory and Inman's 'Nautical Tables'.

Calculation of great circle distances.

The latitudes and longitudes of the epicentre and the observatories are given in Table I below:—

TABLE I.

Locality.	North latitude.	East longitude.
Lagwi pass	25° 49′ 0″	98° 30′ 52″
Alipore (Calcutta)	22° 32′ ..	88° 20′ ..
Dehra Dun	30° 18′ 32″	78° 2′ 56″
Colaba (Bombay)	18° 53′ 36″	72° 48′ 54″
Kodaikanal	10° 13′ 50″	77° 28′ 0″

The respective distances of the observatories from the epicentre (Lagwi pass) are given in Table II below in statute miles and degrees:—

TABLE II.

Distance.	Statute miles.	Degrees.
Lagwi pass to Alipore	677·5	9° 50′ 49″
" " to Dehra Dun	1,279·7	18° 35′ ..
" " to Colaba	1,689	24° 33′ 50″
" " to Kodaikanal	1,739	25° 17′ 41″

The relative positions of the epicentre and the observatories may be seen in Figure 1.

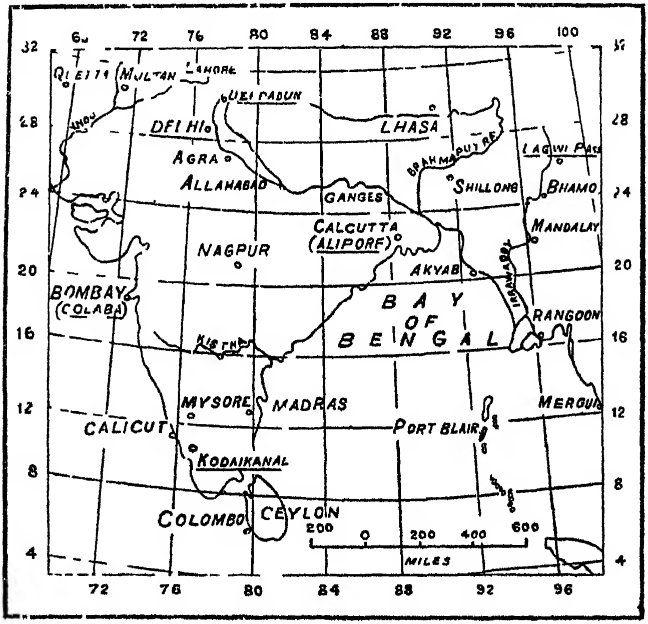


FIG. 1.—Map showing the relative positions of the epicentre, the Lagwi pass, and the observatories of Alipore, Colaba, Dehra Dun and Kodaikanal.

The following are the instrumental details of the seismographs in the respective observatories :—

TABLE III.

Station.	h (metres).	V	To (seconds).	ϵ
Alipore AN	6·4	250	12	1
AE	..	29	30	1
Colaba AN	6	250	12	2·6
AE	..	350	12	2·6
Kodaikanal AE	2,343	9·76	16	1
Dehra Dun AE	..	..	30	..

AN refers to the north-south movement (boom, east-west).
AE refers to the east-west movement (boom, north-south).
h=height above sea-level in metres.
V=magnification.
To=free period of the pendulum (undamped and with pen-friction cut out).
ϵ=ratio of successive positive and negative displacements when the damping apparatus is in action.

II. - SHOCK OF 19TH JANUARY, 1929, AT 11 HOURS 22 MINUTES 55 SECONDS (G. M. T.).

The following records were received from the observatories of Alipore and Colaba, the times being given in Greenwich Mean Time. Burma Standard Time is 6 hours 30 minutes ahead of Greenwich Mean Time.

Seismological records.

TABLE IV.

	Alipore AE.			Colaba AN.		
	Hours.	Minutes.	Seconds.	Hours.	Minutes.	Seconds.
P . .	11	23	34	11	24	53
S . .	11	25	14	11	29	33
L . .	11	26	58	11	33	3
M . .	..	..	..	11	33	18
F . .	11	48	34	12	0	0

The amplitude of the maximum as recorded at Colaba was 3μ and its period was 7 seconds. The epicentral distance was stated to be 745 miles (1200 km.) from Alipore and 1,863 miles from Colaba. These distances may be compared with the following which have been obtained by interpolation from S-P and L-P intervals in tables supplied to this department by the Colaba observatory in connection with the description of the North-West Himalayan Earthquake of the 1st February, 1929.[1] The third value of the epicentral distance has been obtained from interpolation of the S-P intervals in Visser's tables.[2] Visser does not give L-P intervals.

Epicentral distance.

TABLE V.

Station.	S-P.	L-P.	Epicentral distance in degrees.			
			Colaba tables.		Visser's tables.	Actual.
			S-P.	L-P.	S-P.	
	m. s.	m. s.				
Alipore . .	1 40	3 14	8·3°	11·7°	8·4°	9·9°
Colaba . .	4 40	8 10	26·6°	27°	28°	24 6°

[1] A. L. Coulson, *Rec. Geol. Surv. Ind.*, LXIII, p. 437, (1930).
[2] S. W. Visser, *Kon. Mag. Met. Observ. Batavia*, 22, p. 116, (1930).

A glance at Tables II and IV shows that the long waves may be considered as travelling a distance of 24° 33′ 56″ *minus* 9° 50′ 49″=14° 43′ 7″, say 14° 43′ for ease of calculation, in 6 minutes 5 seconds, the difference between the times of arrival (L) of the long waves at either station. This gives the very high velocity of 2·4° per minute, which may be compared with the usual speed of 2·0° to 2·1° per minute.[1]

Velocity of long waves.

If one knows the average speed over a distance equivalent to the difference in the distances from Alipore and from Colaba to the epicentre, then a time of origin can be obtained by calculating how long the long waves would take to travel from the epicentre to Alipore at the assumed speed and subtracting that calculated interval of time from the value of L at Alipore. Alternatively, the same result will be obtained by subtracting from L at Colaba the calculated time interval for the long waves to travel at the assumed speed from Colaba to the epicentre.

Time of origin from L.

The time of origin of the shock of the 19th January, 1929, may thus be determined as 11 hours 22 minutes 55 seconds (G. M. T.).

A reference to Visser's tables will show that a time interval S-P of 1 minute 40 seconds corresponds to a time interval of 2 minutes 8 seconds between the time of origin and the arrival of the P waves (P) at Alipore observatory. The time of origin obtained by this method is thus 11 hours 23 minutes 34 seconds less 2 minutes 8 seconds, *i.e.*, 11 hours 21 minutes 26 seconds (G. M. T.). If one considers the same S-P difference of 1 minute 40 seconds and the time interval of 3 minutes 48 seconds (*vide* Visser's tables) between the time of origin and the arrival of the secondary tremors at Alipore (S), the time of origin obtained will be exactly the same, *viz.*, 11 hours 21 minutes 26 seconds. Consideration of the times of origin derived by this method from S-P at Colaba will show that they again exactly agree, as they obviously should, but are different from the preceding, being 11 hours 18 minutes 46 seconds. The mean of this time and the above is 11 hours 20 minutes 6 seconds (G. M. T.).

Time of origin from S.-P.

[1] Visser, *op. cit.*, pp. 45-47, (1930).

A third method of obtaining the time of origin is by consideration of the actual epicentral distance of the shock from Alipore, and subtracting the value of P which corresponds in Visser's tables to that epicentral distance, from the time P as recorded by the Alipore observatory. The time of 11 hours 21 minutes 6 seconds (G. M. T.) is obtained.

Time of origin from P using actual epicentral distance.

Similarly, by consideration of P at Colaba, the value of 11 hours 19 minutes 20 seconds is determined. The mean of these two times is 11 hours 20 minutes 13 seconds (G. M. T.).

A fourth determination of the time of origin of this shock can be obtained by subtracting from the time S at both Alipore and Colaba, the value of S given in Visser's tables which corresponds to the actual epicentral distance from both observatories. The resultant determinations were 11 hours 20 minutes 50 seconds from Alipore, and 11 hours 19 minutes 44 seconds from Colaba, the mean being 11 hours 20 minutes 17 seconds (G. M. T.).

Time of origin from S using actual epicentral distance.

The above results are summarised in the following table, which gives the different times of origin obtained:—

Summary.

TABLE VI.

Method.	Day.	Greenwich Mean Time.		
		Hours.	Minutes.	Seconds.
L . .	January 19th, 1929 . .	11	22	55
S-P . .	Ditto . .	11	20	6
P . .	Ditto . .	11	20	13
S . .	Ditto . .	11	20	17
Mean of above		11	20	53
Mean of P and S methods . . .		11	20	12

The first time of origin was based upon the proved higher velocity of the long waves; the second, third and fourth determinations were based upon tables. The second necessarily requires the assumption of an epicentral distance smaller than the actual. The third

Time of origin derived from L adopted.

and fourth, which are really variants of the same method, utilise tables in conjunction with the actual epicentral distance; whereas the tables do not agree in giving that epicentral distance. The estimated epicentral distances are generally smaller for Alipore and larger for Colaba than the actual epicentral distances. Accordingly, in spite of the mutual agreement of the times of origin derived from S-P, P and S methods, it is considered that the L value of the time of origin, *viz.*, 11 hours 22 minutes 55 seconds is the more correct. Where records of L for the other shocks described hereafter are available, the times of origin in all cases have been determined by the first method.

Observer's records.

It is unfortunate that there are no reliable records of the local time at which this shock of the 19th of January was felt. The Burma Standard Time corresponding to 11 hours 22 minutes 55 seconds (G. M. T.) is 17 hours 52 minutes 55 seconds (B. S. T.). The shock was universally felt at 'about 6 P.M.' in the Htawgaw subdivision of the Myitkyina district, where it caused much damage. It was also felt at Minya, according to the Township Officer, Paungbyin. The Deputy Commissioner, Bhamo, stated that this shock was felt in the Bhamo district.

III.—SHOCK OF 16TH OCTOBER, 1929, AT 20 HOURS 26 MINUTES 33 SECONDS (G. M. T.).

Seismological records.

The following records were received from the observatories at Alipore, Dehra Dun, Colaba and Kodaikanal, the times being given in G. M. T.:—

TABLE VII.

—	ALIPORE AE.				DEHRA DUN.			COLABA AN.				KODAIKANAL AE.		
	H.	M.	S.	Period (sec.).	H.	M.	S.	H.	M.	S.	Period (sec.).	H.	M.	S.
P .	20	29	0	uncertain.	20	31	10	20	32	51	..	..	..	..
S .	20	31	13	4	20	34	30	20	37	25	..	iL[1] 20	37	[illegible]
L .	20	32	11	12	20	37	20	20	40	43	..	..	..	..
M .	20	34	6	..	20	38	..	20	41	20	8	20	39	[illegible]
F .	21	9	48	..	21	43	..	22	30	..	..	21	28	51

[1] e denotes a gradual commencement of motion.
i denotes a sudden commencement of motion.

The following additional information was given :—

TABLE VIII.

Station.	Amplitude (μ).	Distance (miles).	REMARKS.
Alipore . . .	2,207	894	Great shock.
Dehra Dun	..	1,400	Slight.
Colaba	36	1,794	....
Kodaikanal . . .	40	..	No preliminary tremors.

The estimated epicentral distances may be compared with those given in the following table which have been obtained by the methods explained previously (see p. 359) :—

Epicentral distances.

TABLE IX.

Station.	S-P	L-P	EPICENTRAL DISTANCE IN DEGREES.				
			Colaba tables.		Visser's tables.	Actual.
			S-P.	L-P.	S-P.	
	m. s.	m. s.				
Alipore . .	2 13	3 11	11°	11·7°	11·5°	9·9°
Dehra Dun .	3 40	6 10	19·8°	21·3°	20·3°	18·6°
Colaba . .	4 31	7 49	25·5°	26°	26·6°	24·6°
Kodaikanal .	..	..	..	..	..	25·3°

Velocity of the long waves.

Three values for the velocity of the long waves may be determined by consideration of (1) the difference between L at Colaba and Alipore =1·7°/min. (2) Dehra Dun and Alipore =1·7°/min. (3) Colaba and Dehra Dun =1·8°/min. These results agree amongst themselves but they are much lower than the usual rate (2-2·1°/min.) and especially lower than the rate of propagation of the long waves of

the shock of the 19th January, 1929 (2·1°/min.). The time given for *i*L at Kodaikanal is not taken into consideration as it is obviously not L, being 2 minutes 55 seconds earlier than L for Colaba which is 0·7° less distant from the epicentre. It is possibly S.

Time of origin from L.

Three values of the time of origin may likewise be determined by consideration of the paths from the epicentre to each observatory, supposing the long waves to have a uniform velocity. The following times were obtained by consideration of (1) Colaba and Alipore = 20 hours 26 minutes 28 seconds; (2) Dehra Dun and Alipore =20 hours 26 minutes 22 seconds; and (3) Colaba and Dehra Dun =20 hours 26 minutes 50 seconds. The mean time of origin, from L, is thus 20 hours 26 minutes 33 seconds (G. M. T.).

Time of origin by P and S methods.

It is interesting to compare this time of origin with the times obtained by deducting from the recorded P and S times, the times P and S, derived from Visser's tables, for the preliminary and secondary tremors respectively to travel from the actual epicentre to the observatories (third and fourth methods used in shock of 19th January 1929). The following results were obtained:—

TABLE X.

Station.	Method.	Time of origin.		
		H.	M.	S.
Alipore	P	20	26	32
Dehra Dun	P	20	26	46
Colaba	P	20	27	21
Mean of above	P	20	26	53
Alipore	S	20	26	59
Dehra Dun	S	20	27	2
Colaba	S	20	27	36
Mean of above	S	20	27	12
Mean of both methods . . .	P & S	20	27	2

This time of origin—20 hours 27 minutes 2 seconds (G. M. T.)—is considerably later than that—20 hours 26 minutes 33 seconds (G. M. T.)—obtained by consideration of L, and is not considered as likely to be correct as the latter because the P and S waves were slower than usual. This is evidenced by the fact that determinations of the epicentre by S-P methods give distances greater than the actual distances.

The Burma local time corresponding to 20 hours 26 minutes 33 seconds (G. M. T.) on the 16th October, 1929, is 2 hours 56 minutes 33 seconds (B. S. T.) on the 17th October, 1929. There are, unfortunately, no accurate records of the time at which this earthquake was felt in the North-East Frontier Region of Burma but all agree in it being about 3 A.M. Three shocks in quick succession, however, were felt at Tengyueh in China, some 52 miles almost due south of the Lagwi pass at 3·20 A.M. on the 17th. This time is probably incorrect.

IV.—SHOCK OF 15TH DECEMBER, 1929 AT ABOUT 20 HOURS (G. M. T.).

The following records were obtained from the observatories at Alipore and Colaba, the times being given in G. M. T. The shock was not recorded at either Dehra Dun or Kodaikanal.

Seismological records.

TABLE XI

	Alipore AE.			Colaba AN.			Distance (miles).
	H. M. S.	Period (sec.).	Distance (miles).	H. M. S.	Period (sec.).	Amplitude (μ).	
P .	19 56 57	uncertain	606	20 2 3	..	..	1,242
S .	19 58 46	6	..	20 5 22	..	..	..
L .	..	..	..	20 7 1	..	..	..
M .	..	..	..	20 7 26	10	2	..
F .	20 18 46	..	..	20 28 ..	..	..	..

Epicentral distances.

The estimated epicentral distances may be compared with those in the following table which have been obtained by the methods explained previously :

TABLE XII.

Station.	S.-P.	L.-P.	Epicentral distance in degrees.			
			Colaba tables.		Visser's tables	Actual.
			S.-P.	L.-P.	S.-P.	
	m. s.	m. s.				
Alipore . .	1 49	..	9°	..	9·2°	9·9°
Colaba . .	3 19	4 58	17·5°	17·6°	18°	24·6°

Alternative conclusions.

Thus the epicentre of this shock is about the same distance from Alipore as the distance of the Lagwi Pass from this observatory : but according to the Colaba records, the shock was only some 18° distant from Colaba. Thus there are two alternative conclusions :- (1) The records of both observatories are those of a shock different from that which occurred on the North-East Frontier of Burma at about 2 hours 30 minutes (B. S. T.) on the morning of the 16th December 1929, corresponding to about 20 hours (G. M. T.) on the 15th December. (2) The Colaba records have been confused. The first alternative is the more probable and the records are not discussed further.

Observer's times.

The local times (B. S. T.) at which the shock was felt vary greatly, as the following table shows :—

TABLE XIII.

Place.	Time (B. S. T.)	Observer.
Laukhaung	2·30	Sub-postmaster.
	2·29	Post Commander.
Tengyueh, China	2·30	British Consul.
Fort Harrison	2·30	Post Commander.
Htawgaw	2·32	H. L. Chhibber.
	2·30	Mahtab Singh, Overseer.
N'Pumbum	2·40	Signaller-in-Charge.
Mangai	2·10	Post Commander.
Fort Morton	2·00	Post Commander.
Seniku	1·53	Jemadar, Ration Dump.

There are post and telegraph offices at Laukhaung, Fort Harrison, Fort Morton and Htawgaw. A mistake in the time appears to have been made at Fort Morton. The mistake at Semku is understandable in view of the absence of any reliable time. So there is good evidence for regarding this shock to have occurred at about 2·30 on the morning of the 16th (B. S. T.), or 20 hours (G. M. T.) on the 15th December 1929.

V.—SHOCK OF 28TH FEBRUARY, 1930, AT 22 HOURS 47 MINUTES 39 SECONDS (G. M. T.).

Seismological records.

The following records were obtained from the observatories of Alipore and Colaba, the times being given in G. M. T. The shock was not recorded at either Dehra Dun or Kodaikanal.

TABLE XIV.

	Alipore AE.					Colaba AN.					
	H.	M.	S.	Period.	Distance.	H.	M.	S.	Period.	Amplitude.	Distance.
				(secs).	(miles).				(secs).	(μ)	(miles).
P .	eP[1] 22	52	21	uncertain.	487	22	58	40	..	..	1,345
S .	..	..	..	..	..	23	2	15	..	..	..
L .	22	54	21	6	..	23	4	22	..	..	..
M .	..	..	..	..	..	23	5	20	9	3	..
F .	23	27	31	..	..	23	44	0	..	..	..

[1] *See* footnote on page 362.

Epicentral distances.

The estimated epicentral distances may be compared with those in the following table which have been obtained by the methods explained previously :—

TABLE XV.

Station.	S.-P.	L.-P.	Epicentral distance in degrees.			
			Colaba tables.		Visser's tables S.-P.	Actual.
			S.-P.	L.-P.		
	m. s.	m. s.				
Alipore . .	..	2 0	..	7·3°	..	9·9°
Colaba . .	3 35	5 42	19·5	22·7°	19·8°	24·6°

The epicentral distances as obtained from the S-P method differ largely from those by the L-P method, which more closely approximate to the actual distance, in spite of the fact that eP for Alipore is indefinite.

Velocity of long waves.

The velocity of the long waves, calculated from the difference in arrival of the long waves at Alipore and Colaba and the difference between the respective distances of those stations from the actual epicentre, may be determined as 1·5°/min. This velocity is even slower than that of the long waves of the shock of the 16th October, 1929 (1·7°/min.) and very considerably lower than that of the long waves of the shock of the 19th January, 1929 (2·4°/min.).

Time of origin.

Assuming, however, that this velocity is correct and that the long waves travelled with that speed from the epicentre to Alipore (or to Colaba), the time of origin of the shock may be determined as 22 hours 47 minutes 39 seconds (G. M. T.) on the 28th February, 1930, or 5 hours 17 minutes 39 seconds (B. S. T.) on the 1st March, 1930.

Observers' records.

Observers' records in the Frontier Region of Burma appear to indicate that there were two shocks of considerable magnitude at about that time, there being an interval of about 20 minutes between them. The following table shows such times as were recorded:—

TABLE XVII

Station.	Time (B. S. T.)	Observer.
Laukhaung	5·20	N. N. Nair, Sub-postmaster.
	5·20	Post Commander.
	5·40	N. N. Nair, Sub-postmaster.
	5·40	Post Commander.
Htawgaw	5·25	Mahtab Singh, Overseer.
Lagwibum	5·45	Post Commander.
Langyang	5·15	C. Harris.
	5·35	C. Harris.
Myitkyina	5·20	F. S. Grose.
	5·37	F. S. Grose.
Punlumbum	5·06	Post Commander.
Fort Morton	5·15	N. D. Sharma, Sub-postmaster.
N'Pumbum	5·15	Post Commander.
Mangai	5·10	Post Commander.
Fort Harrison	5·30	Post Commander.
	5·45	Post Commander.

VI.—SHOCK OF 28TH APRIL, 1930, AT 18 HOURS 33 MINUTES 17 SECONDS (G. M. T.).

Seismological records.

The following records were received from the observatories of Alipore, Dehra Dun, Colaba and Kodaikanal, the times being given in G. M. T.:—

TABLE XVII.

	Alipore AE.				Dehra Dun.			Colaba AN.				Kodaikanal AE.		
	H.	M.	S.	Period (sec.).	H.	M.	S.	H.	M.	S.	Period (sec.).	H.	M.	S.
P .	18	36	28	5	18	39	30	18	40	3	..	..	..	..
S .	18	38	18	7	18	43	00	18	44	32	..	eL 18	44	42
L .	18	39	42	14	18	45	10	18	47	48	..	..	..	..
M .	18	41	36	..	18	46	00	18	48	16	9	18	52	00
F .	19	26	28	..	19	40	00	20	23	00	..	19	27	24

The following additional information was given:—

TABLE XVIII.

Station.	Amplitude.	Distance.	REMARKS.
	(μ)	(miles).	
Alipore	2,241	646	Moderate shock.
Dehra Dun . . .	..	1,300	Slight shock.
Colaba	48	1,759	
Kodaikanal . . .	60	..	No preliminary tremors.

Epicentral distances.

The estimated epicentral distances may be compared with those given in the following table which have been obtained by the methods explained prev-

TABLE XIV.

Station.	S.-P.	L.-P.	EPICENTRAL DISTANCE IN DEGREES.			
			Colaba tables.		Visser's tables S.-P.	Actual.
			S.-P.	L.-P.		
	m. s.	m. s.				
Alipore . .	1 50	3 14	9°	11·7°	9·3°	9 9°
Dehra Dun .	3 30	5 40	19°	19 7°	19·2°	18·6°
Colaba . .	4 29	7 15	25·5°	25·8°	26 2°	24 6°
Kodaikanal	..	..	..	..	..	25·3°

Velocity of long waves.

Three values of the velocity of the long waves of this shock may be determined by consideration of the differences between L at (1) Colaba and Alipore=1·8°/min.; (2) Dehra Dun and Alipore=1·6°/min.; (3) Colaba and Dehra Dun=2·3°/min. The value of *e*L given for Kodaikanal has not been taken into consideration, as it cannot be regarded as L inasmuch as it is 3 minutes 6 seconds earlier than L at Colaba, which is 0·7° less distant from the epicentre. It may be S. These velocities average 1·9°/min., which agrees fairly well with the velocity of the long waves of the shock of the 16th October, 1929. However, the Colaba-Alipore determination agrees remarkably well with the latter shock and it is considered best to neglect the Dehra Dun values. Accordingly, the long waves of this shock of 28th April, 1930, are regarded as having a velocity of 1·8°/min.

Time of origin.

Three values of the time of origin of this shock of the 28th April, 1930, may likewise be obtained by consideration of the paths from the epicentre to each station, supposing the long waves to have a uniform velocity. The

following are the results by consideration of (1) Colaba and Alipore =18 hours 33 minutes 17 seconds; (2) Dehra Dun and Alipore =18 hours 33 minutes 32 seconds; and (3) Colaba and Dehra Dun=18 hours 33 minutes 59 seconds. There is a large discordance in these results as is to be expected from the different values of the velocity utilised. It is proposed to neglect the Dehra Dun values and to consider the time of origin derived from Colaba and Alipore as more likely to be correct, *i.e.*, 18 hours 33 minutes 17 seconds (G. M. T.).

The B. S. T. corresponding to this time of origin is 1 hour 3 minutes 17 seconds on April 29th, 1930. This agrees well with the recorded times at which the shock was experienced in the North-East Frontier Region of Burma:—

Observers' records.

TABLE XX.

Station.	Time (B. S. T.)	Observer.
Laukhaung	1·11	N. N. Nair, Sub-postmaster.
	1·05	Post Commander.
Htawgaw	1·00	C. C. Harris.
Myitkyina	1·00	D. Wooltorton.
Fort Hertz (Putao) . . .	1·15	Post Commander.
	1·15	Assistant Superintendent.
Chingnambum	1·05	Post Commander.
Fort Morton (Sima) . . .	1·00	Sub-postmaster.
N'Pumbum	0·35	Post Commander.
Mangai	1·33	Do.

It is interesting to note that another severe shock was felt in this region at about 13 hours 15 minutes on the same day.

VII.—SHOCK OF 21ST SEPTEMBER, 1930, AT 23 HOURS 2 MINUTES 33 SECONDS (G. M. T.).

Seismological records.

The following records were received from the observatories of Alipore, Dehra Dun, Colaba and Kodaikanal, the times being given in G. M. T. :—

TABLE XXI.

	Alipore. AE.				Dehra Dun.						Colaba AN.	Kodaikanal AE.		
	H.	M.	S.	Period. (sec.)	H.	M.	S.	H.	M.	S.	Period. (sec.)	H.	M.	S.
P .	23	6	16	5	23	8	20	23	9	39	..	eP 23	10	24
S .	23	7	52	7	23	11	40	23	14	2	..	iL 23	14	42
L .	23	8	27	14	23	14	10	23	17	16	..	..	..	..
M .	23	10	17	..	23	15	00	23	17	44	6	23	27	36
F .	23	56	17	..	3	36	00	1	46	00	..	0	58	18

The times given for F for Dehra Dun, Colaba and Kodaikanal are for the date 22nd September, 1930. The following additional information was received :—

TABLE XXII.

Station.	Amplitude (μ).	Distance (miles).	REMARKS.
Alipore . . .	5,069	556	Great shock.
Dehra Dun . .	..	1,300	Do.
Colaba . . .	12	1,725	
Kodaikanal . .	240	..	No preliminary tremors.

The estimated epicentral distances may be compared with those given in the following table which have been obtained by the methods described previously :—

Epicentral distances.

TABLE XXIII.

Station.	S.-P.	L.-P.	Epicentral distance in degrees. Colaba tables. S.-P.	Colaba tables. L.-P.	Visser's tables. S.-P.	Actual.
	m. s.	m. s.				
Alipore . .	1 36	2 11	8·0°	8·0°	8·1°	9·9°
Dehra Dun .	3 20	5 50	17·5°	20·0°	18·1°	18·6°
Colaba . .	4 23	7 37	25·0°	25·3°	25·5°	24·6°
Kodaikanal .	..	..	..	..	..	25·3°

The time given as *i*L for Kodaikanal cannot be considered as L as it is 2 minutes 34 seconds less than L for Colaba which is 0·7° less distant from the epicentre than Kodaikanal. It may be S.

Velocity of long waves.

The three values of the velocity of the long waves are as follows when determined by consideration of the differences between L at (1) Colaba and Alipore=1·7°/min.; (2) Dehra Dun and Alipore=1·5°/min.; and (3) Colaba and Dehra Dun=1·9°/min. The average velocity of the long waves is thus 1·7°/min., which is the same as that found by consideration of the L records of Alipore and Colaba, and which agrees with those values for the velocity of the long waves of the shock of the 16th October, 1929; it is very near that of the shock of 28th April, 1930.

Time of origin.

Three values of the time of origin of this shock may likewise be obtained by consideration of the paths from the epicentre to each station, supposing the long waves to have a uniform velocity. These are (1) Colaba and Alipore=23 hours 2 minutes 33 seconds; (2) Dehra Dun and Alipore =23 hours 2 minutes 0 seconds; and (3) Colaba and Dehra Dun =23 hours 4 minutes 32 seconds. The Colaba-Alipore time is more likely to be correct, and so this shock is regarded as having occurred

at 23 hours 2 minutes 33 seconds G. M. T. on the 21st September, 1930.

The B. S. T. corresponding to this time is 5 hours 32 minutes 33 seconds on the 22nd September, 1930, which agrees well with the observers' recorded times in the following table :—

Observers' records.

TABLE XXIV.

Station.	Time (B. S. T.)	Observer.
Hpimaw	5·35	Post Commander.
Laukhaung	5·35	N. N. Nair, Sub-postmaster.
	5·35	Post Commander.
Mangai	(?) 6·07	Do.
Shwegu (Bhamo district)	5·30	—
Bhamo	5·33	Deputy Commissioner.

VIII.—SHOCK OF 2ND DECEMBER, 1930, AT 7 HOURS 0 MINUTE 30 SECONDS (G. M. T.).

The following records were received from the observatories of Alipore, Dehra Dun, Colaba and Kodaikanal, the times being given in G. M. T. :-

Seismological records.

TABLE XXV.

	Alipore AN.			Colaba AN.			Colaba AE.			Dehra Dun.			Kodaikanal AE.		
	H	M	S	H	M	S	H	M	S	H	M	S	H	M	S
P .	7	3	44	7	6	47	7	6	17	7	4	50		..	
S .	7	5	34	7	11	11	7	11	14	7	8	30	iP 7	11	30
L .	7	6	6	7	11	29	7	14	20	7	11	10	eL 7	17	00
M .	7	11	2	7	15	54	7	20	5	7	12	00	7	23	42
F .	8	18	2	8	41	00	8	11	00	7	52	00	7	37	36

The following additional information was received:—

TABLE XXVI.

Station.	Amplitude (μ).	Period (sec).	Distance (miles).	REMARKS.
Alipore	M 181	P 5 S 7 L 10	616	Great shock.
Colaba AN . .	M 30	M 8	1,759	
Colaba AE . .	M 14	M 9	1,759	
Dehra Dun . . .	..	..	1,400	Slight shock.
Kodaikanal . . .	M 60	..	..	

The records of the N-S and the E-W components at Colaba agree except as regards M. Once again *i*P for Kodaikanal cannot be taken as P. It may be S.

Epicentral distances.

The estimated epicentral distances which have been obtained by the methods explained previously may be compared with those given in the following table:—

TABLE XXVII.

Station.	S.-P.	L.-P.	EPICENTRAL DISTANCE IN DEGREES. Colaba tables. S.-P.	Colaba tables. L.-P.	Visser's tables. S.-P.	Actual.
	m. s.	m. s.				
Alipore . .	1 30	2 22	9·0°	8·8°	9·3°	9·9°
Dehra Dun .	3 40	6 20	20·0°	21·7°	20·3°	18·6°
Colaba . .	4 27	7 42	23·5°	25·7°	26·0	24·6
Kodaikanal .	..	..	..	..	..	25·3°

Velocity of long waves.

The three values of the velocity of the long waves are as follows when determined by consideration of the differences between L at (1) Colaba and Alipore=1·7°/min.; (2) Dehra Dun and Alipore=1·7°/min.; and (3) Colaba and Dehra Dun=1·8°/min. This velocity (average=1·7°/min.) agrees with that found for the long waves of the shocks of the 16th October, 1929, and the 21st September, 1930, and is near that of the shock of the 28th April, 1930 (1·8°/min.).

Time of origin.

Three values of the time of origin of the shock may likewise be determined by consideration of the paths from the epicentre to each station, supposing the long waves to have a uniform velocity. These are (1) Colaba and Alipore=7 hours 0 minute 16 seconds; (2) Dehra Dun and Alipore=7 hours 0 minute 23 seconds; and (3) Colaba and Dehra Dun=7 hours 0 minute 52 seconds. The mean of these three times is 7 hours 0 minute 30 seconds (G. M. T.) on the 2nd December, 1930.

Observers' records.

The B. S. T. corresponding to this time is 13 hours 30 minutes 30 seconds on the 2nd December, 1930, which agrees well with the times recorded by observers in the epicentral tract:—

TABLE XXVIII.

Station.	Time (B. S. T.)	Observer.
Htawgaw	13·32	Sub-postmaster.
	13·35	Post Commander.
Mangai	13·35	Do.
Laukhaung	13·35	Do.
	13·32	N. N. Nair, Sub-postmaster.
Hpimaw	13·30	Post Commander.
	13·35	Sub-postmaster.

IX.—THE LONG WAVES.

Summary of previous results.

The foregoing results may conveniently be summarised in tabular form as follows:—

TABLE XXIX.

Time of shock (G. M. T.).						Velocity of long waves in degrees per minute.		
H.	M.	S.	Day.	Month.	Year.	I.	II.	III.
11	22	55	19	January . .	1929	2·4°	..	..
20	26	33	16	October . .	1929	1·7°	1·7°	1·8°
20	0	0	15	December . .	1929	..	..	..
22	47	39	28	February . .	1930	1·5°	..	..
18	33	17	28	April . . .	1930	1·8°	1·6°	2·3°
23	2	33	21	September . .	1930	1·7°	1·5°	1·9°
7	0	30	2	December . .	1930	1·7°	1·7°	1·8°

The velocity given in column I is derived from consideration of the difference between L at Colaba and Alipore; that in II from Dehra Dun and Alipore; and that in III from Colaba and Dehra Dun. It is considered that I is the most reliable, and the velocities in columns II and III for the shocks of the 28th April and 21st September, 1930, have been discarded in favour of that in column I for these shocks in the determination of the time of origin.

The following table shows the time in minutes and seconds which the P, S and L waves would take to travel to the respective observatories, assuming the times of origin given before in Table XXIX to be correct. It will be remembered that in all cases, these were obtained from a study of the long waves.

Times of P, S and L from epicentre.

TABLE XXX.

Shock.	Alipore.			Colaba.			Dehra Dun.			Kodaikanal.	
	P.	S.	L.	P.	S.	L.	P.	S.	L.	P.	S.
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
19th January, 1929 . .	0 39	2 19	4 03	1 58	6 38	10 08	..	..	..	..	..
16th October, 1929 . .	2 27	4 40	5 38	6 21	10 52	14 10	4 37	8 17	10 47	..	11 15
28th February, 1930 . .	4 42	..	6 42	11 01	14 36	16 43	..	..	..	..	..
28th April, 1930 . . .	3 11	5 01	6 25	6 13	9 43	14 31	6 13	9 43	11 53	..	11 25
21st September, 1930 . .	3 43	5 19	5 54	7 06	11 29	14 43	4 47	8 07	10 37	7 51	12 09
2nd December, 1930 . .	3 14	5 04	5 36	6 17	10 44	13 59	4 20	8 00	10 40	..	11 00

The following adjustments have been made for the Kodaikanal records:—16th October, 1929—*i*L=S; 28th April, 1930—*e*L=S; 21st September, 1930—*e*P=P and *i*L=S; and 2nd December, 1930—*i*P=S. The records from Alipore and Colaba for the shock of the 15th December, 1929, have been discarded.

Graphical representation of L.

The values for L given in Table XXX have been plotted against epicentral distance in Figure 2.

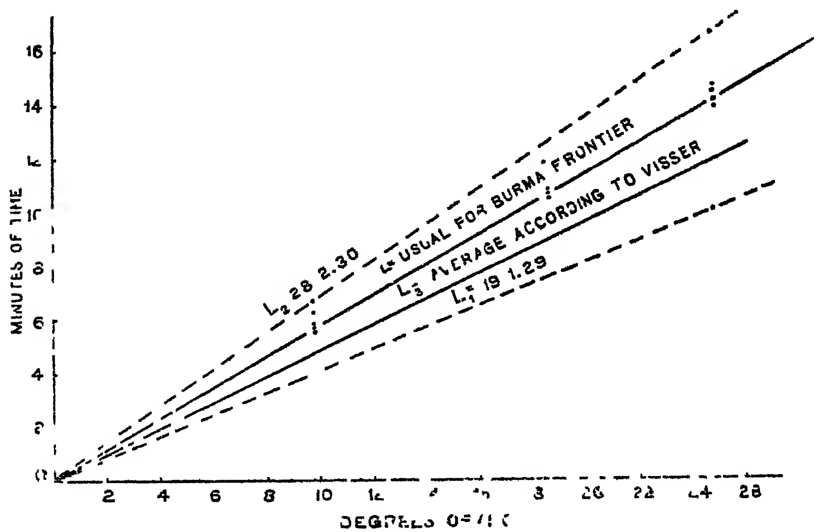


FIG. 2.—Times taken by the long waves to travel from the epicentre to respective observatories (L), plotted against epicentral distances in degrees of arc.

It would appear that the long waves of the earthquakes originating in the Lagwi pass generally have a velocity of propagation in the neighbourhood of 1·7 degrees per minute. This corresponds to a velocity of less than 3·2 kilometres per second or about 2 miles per second. On the other hand, the long waves of the shock of the 19th January, 1929, had the very high velocity of 2·4 degrees per minute and the long waves of the shock of the 28th February, 1930, had the very low velocity of 1·5 degrees per minute. It is suspected that the

Usual velocity of long waves, 1.7°/min.

variation in the depth of the focus of these shocks below the epicentral tract was sufficient to cause these differences in the rate of propagation of the long waves. Possibly the shallower the focus, the less is the velocity of the long waves, and *vice versa.*

North-West Himalayan earthquake of 1st February, 1929.

It is interesting to compare these results with those obtained by the author in the case of the earthquake of the 1st February, 1929, in the North-West Himalayas.[1] The long waves of that shock had the high velocity of 4·6 kilometres per second, which is equivalent to about 2·86 miles per second, or a little less than 2·5 degrees per minute. This agrees very well with the velocity of the long waves of the shock of the 19th January, 1929, but is generally higher than the velocities of the long waves of the other shocks in the North-East Frontier Region of Burma.

Pegu earthquake of 5th May, 1930.

In his note concerning the long distance wave speeds of the Pegu (Burma) earthquake of May 5th, 1930, Mr. Leicester obtains a velocity of 2·65 miles per second[2] which is intermediate between the usual velocity of 2·4 miles per second and those of the shocks of 1st February, 1929, in the North-West Himalayas, and the 19th January, 1929, in the North-East Frontier Region of Burma.

Visser's results.

In his interesting work on the distribution of earthquakes in the Dutch East Indies, Visser[3] notes that the majority of observations on the speed of the long waves places their velocity between 2·0 and 2·1 degrees per minute. He also notes that the average speed of 991 observations of the long waves across the Pacific is 2·039°/min. ±0·107, or 3·78 kilometres per second, which agreed with the mean of 2·05°/min. found formerly for earthquakes in the Malay Archipelago. He also obtained the mean speed of waves along the Eurasiatic Continent as 2·014°/min. ±0·116, or 3·72 kilometres per second. These velocities are considerably higher than the usual 1·7°/min. found for shocks originating in the North-East Frontier Region of Burma.

[1] A. L. Coulson, *Rec. Geol. Surv. Ind.*, LXII, pp. 279-289, (1930); *op. cit.*, LXIII, pp. 434-443, (1930).

[2] P. Leicester, *op. cit.*, LXV, p. 280, (1932).

[3] S. W. Visser, *Kon. Mag. Met. Observ. Batavia*, 26, pp. 44-48, (1930).

X.—THE PRELIMINARY AND SECONDARY TREMORS.

Graphical representation of P and S derived from L.

In Figure 3, the values of P given in Table XXX have been plotted against epicentral distance; whilst in Figure 4, the values of S given in that table have likewise been plotted against epicentral distance.

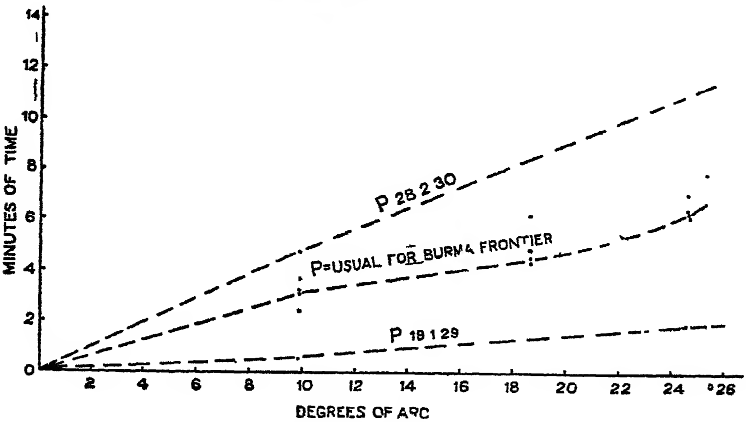


FIG. 3.—Times taken by the preliminary tremors to travel from the epicentre to the respective observatories (P), calculated from L, plotted against epicentral distance in degrees of arc.

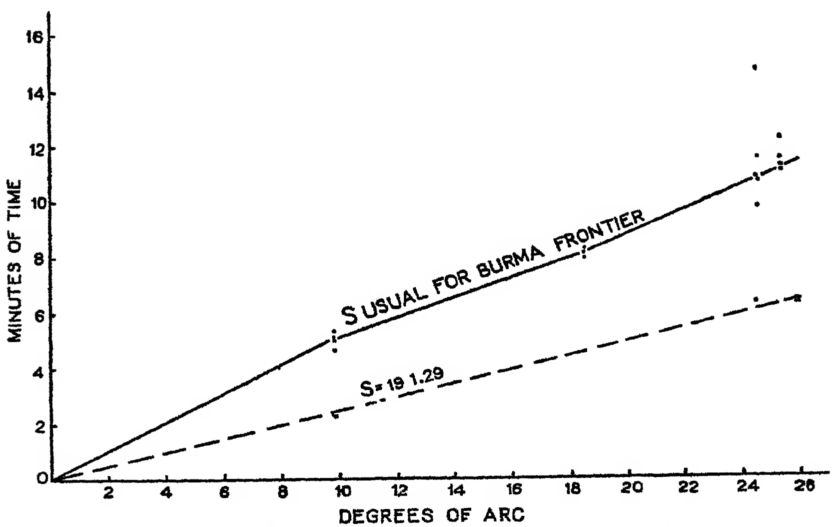


FIG. 4.—Times taken by the secondary tremors to travel from the epicentre to the respective observatories (S), calculated from L, plotted against epicentral distance in degrees of arc.

It must be remembered that these times have been calculated from a study of the long waves, resulting in a zero time which has been adopted in this paper. It is informative to compare these graphs with others which are independent of the records.

Table of S-P.

In Table XXXI below, the time intervals, S-P, for the various earthquakes have been summarised :—

TABLE XXXI.

Shock.	Alipore S-P.	Colaba S-P.	Dehra Dun S-P.	Kodaikanal S-P.
	m. s.	m. s.	m. s.	
19th January, 1929 . .	1 40	4 40	..	
16th October, 1929 . .	2 13	4 31	3 40	
28th February, 1930 . .	..	3 35	..	
28th April, 1930 . . .	1 50	4 29	3 30	
21st September, 1930 . .	1 36	4 23	3 20	4 18
2nd December, 1930 . .	1 50	4 27	3 40	

Graphical representation of S-P.

These intervals of S-P have been plotted against epicentral distance in Figure 5 below.

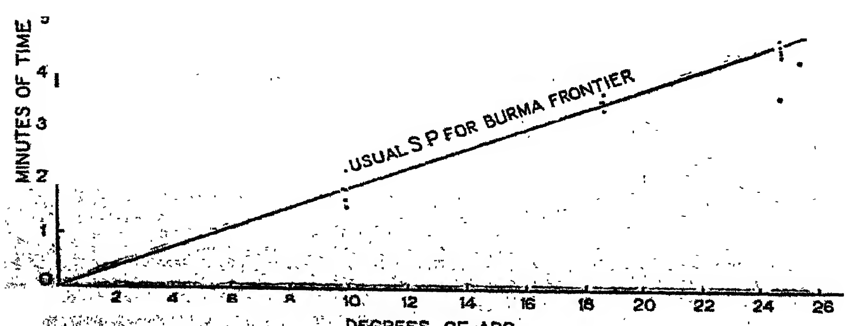


FIG. 5.—Intervals, S-P, plotted against epicentral distance in degrees of arc.

These results would appear to show extraordinarily good agreement but it must be remembered that such agreement does not necessarily mean that the times taken for the P and S waves to reach any particular observatory from our epicentre are constant. This is far from being the case, as will be seen from the following.

Table of P-P and S-S.

In Table XXXII, the time intervals between the recorded P for the same shock at each pair of observatories have been tabulated and the same done for the time differences between S at each pair of observatories.

Graphical representation of P-P and S-S.

In Figure 6, the time intervals, P-P, have been plotted against the differences in degrees of arc between the respective distances of the observatories from the epicentre; whilst in Fig. 7, the values of S-S given in Table XXXII have been plotted similarly.

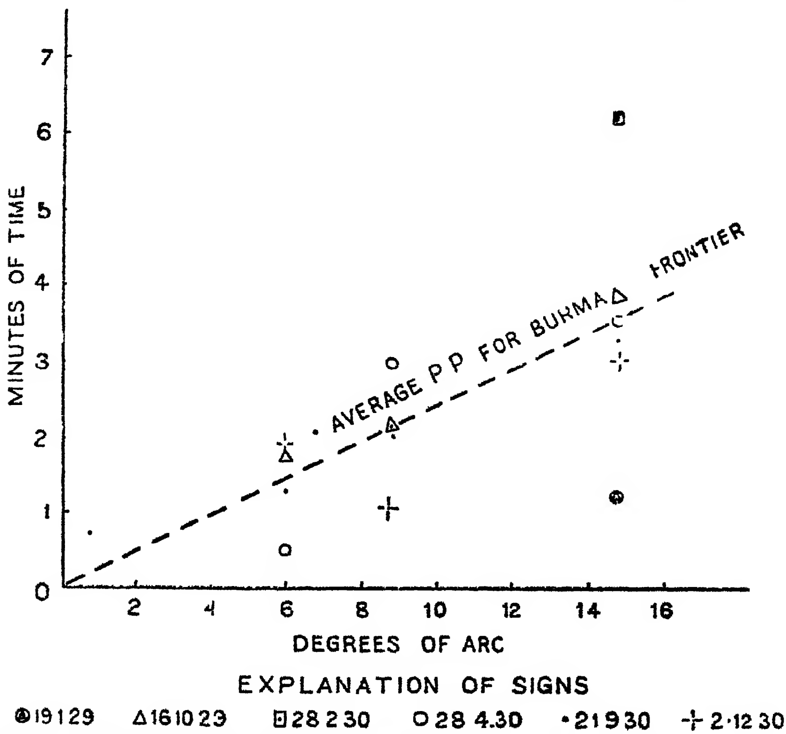


FIG. 6.—Differences of time between the arrival of the preliminary tremors of the same shock at each of a pair of observatories (P-P), plotted against the differences in degrees of arc between the respective distances of the observatories from the epicentre.

TABLE XXXIII.

Distance.	Colaba-Alipore. 14° 43′		Dehra Dun-Alipore. 8° 44′		Colaba-Dehra Dun. 5° 59′		Kodaikanal-Alipore. 15° 27′		Kodaikanal-Dehra Dun. 6° 43′		Kodaikanal-Colaba. 0° 44′	
Shock.	P-P.	S-S.	P-P.	S-S.	P-P.	S-S.	P-P.	S-S.	P-P.	S-S.	P-P.	S-S.
	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.	m. s.
19th January, 1929	1 19	4 19	..	..	..	..	..	..	..	..	..	..
16th October, 1929	3 54	6 12	2 10	3 37	1 44	2 35	..	..	..	..	..	..
28th February, 1930	6 19	..	..	..	..	..	..	..	..	..	..	..
28th April, 1930 .	3 35	6 14	3 02	4 42	0 33	1 32	..	6 24	..	1 42	..	0 10
21st September, 1930	3 17	6 10	2 04	3 48	1 19	2 22	4 08	6 50	2 04	3 02	0 45	0 40
2nd December, 1930	3 04	5 40	1 06	2 56	1 57	2 44	..	5 56	..	3 00	..	0 16

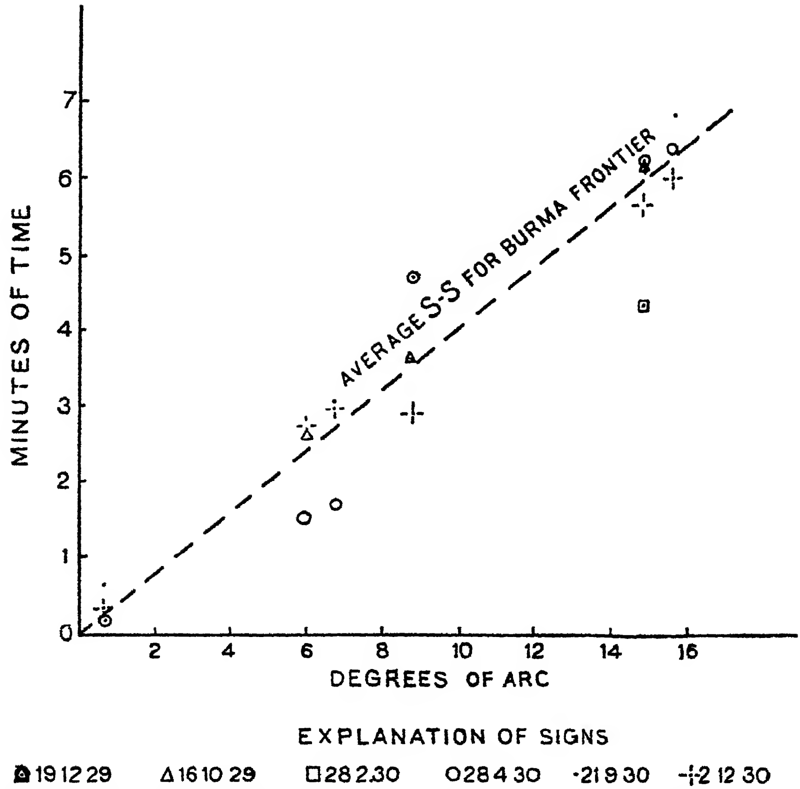


FIG. 7.—Differences of time between the arrival of the secondary tremors of the same shock at each of a pair of observatories (S-S), plotted against the differences in degrees of arc between the respective distances of the observatories from the epicentre.

It would appear from Figures 5, 6 and 7 that whilst the interval, S-P, for any particular observatory was remarkably constant for the whole series of shocks experienced in the North-East Frontier Region of Burma during 1929 and 1930, yet the velocities of P and of S varied greatly in individual shocks of the series. In other words, whilst the velocity of the preliminary tremors of different shocks varied, the velocity of the secondary tremors of the same shock varied sympathetically with that

Conclusion.

of the former tremors. Thus if the points in Figure 7 for the shocks of either 28th April, 1930, or 21st September, 1930, be joined, the resultant curves are very similar to those obtained by joining the points for the same shock in Figure 6.

Finally, it would appear that if depth of focus has been responsible for the variations in the rate of propagation of the preliminary and secondary tremors, as was suggested for the long waves, then these tremors vary far more than do the long waves under similar changes of depth of focus.

XI.—SUMMARY.

The seismological records of eight shocks which occurred in the North-East Frontier Region of Burma during 1929 and 1930 have been examined. The records of one of these were rejected as probably being those of a shock which occurred elsewhere at about the same time.

The exact times of origin of six shocks have been determined by a study of the time intervals between the arrival of the long waves at different observatories and by assuming that the velocity of the long waves thus obtained was maintained uniformly from the epicentre to the recording observatories.

The usual velocity of the long waves of the shocks under examination was about 1·7 degrees per minute, which corresponds to a velocity of less than 3·2 kilometres per second or about 2 miles per second. This is considerably less than the usual velocity of the long waves of 2·0-2·1 degrees per minute given by Visser. The long waves of one shock, however, had the very high velocity of 2·4 degrees per minute, and those of another shock possessed the very low velocity of 1·5 degrees per minute. Depth of focus has been suggested as a cause of these varying velocities.

It was found that whilst the interval between the arrival of the preliminary and the secondary tremors of any shock at any particular observatory was approximately constant, yet the velocities of both of those tremors varied greatly in different shocks.

The records of the observatories of Alipore, Dehra Dun and Colaba for the six shocks have been summarised in Table XXXIII below :—

TABLE XXXIII.

Table.	Observatory.	S.-P.	L.-P.	Epicentral distance in degrees.			
				From Colaba tables.		Visser.	Actual.
				S.-P.	L.-P.	S.-P.	
		m. s.	m. s.				
V	Alipore . .	1 40	3 14	8·3	11·7	8·4	9·9
IX	Do. . .	2 13	3 11	11·0	11·7	11·5	9·9
XV	Do. . .	..	2 0	..	7·3	..	9·9
XIX	Do. . .	1 50	3 14	9·0	11·7	9·3	9·9
XXIII	Do. . .	1 36	2 11	8·0	8·0	8·1	9·9
XXVII	Do. . .	1 50	2 22	9·0	8·8	8·1	9·9
V	Dehra Dun .	..	..	..	..	..	18·6
IX	Do. .	3 40	6 10	19·8	21·3	20·3	18·6
XV	Do. .	..	..	..	..	..	18·6
XIX	Do. .	2 30	5 40	19·0	19·7	19·2	18·6
XXIII	Do. .	3 20	5 50	17·5	20·0	18·1	18·6
XXVII	Do. .	3 40	6 20	20·0	21·7	20·3	18·6
V	Colaba . .	4 40	8 10	26·6	27·0	28·0	24·6
IX	Do. . .	4 31	7 49	25·5	26·0	26·6	24·6
XV	Do. . .	3 35	5 42	19·5	22·7	19·8	24·6
XIX	Do. . .	4 29	7 45	25·5	25·8	26·2	24·6
XXIII	Do. . .	4 23	7 37	25·0	25·3	25·5	24·6
XXVII	Do. . .	4 27	7 42	25·5	25·7	26·0	24·6

The records taken from Tables V and XV are of abnormal shocks (19th January, 1929, and 28th February, 1930), whilst those from Tables IX, XIX, XXIII and XVII are of more or less normal shocks (16th October, 1929; 28th April, 1930; 21st September, 1930; and 2nd December, 1930).

NOTE ON A GLACIER IN THE ARWA VALLEY, BRITISH GARHWAL. BY L. B. GILBERT, B. SC. (LONDON), EXECUTIVE ENGINEER, KUMAON PROVINCIAL DIVISION AND J. B. AUDEN, M A. (CANTAB.), *Assistant Superintendent, Geological Survey of India.* (With Plates 15 to 21).

CONTENTS.

I.—INTRODUCTION.

After Mr. F. S. Smythe and his party had climbed Mount Kamet in June 1931, they turned their attention to the area west of Kamet, and ascended the Arwa valley in order to explore the peaks forming the boundary between British and Tehri Garhwal. In the London 'Times' of September 24th, 1931, Mr. Smythe published an article entitled 'The Conquest of Kamet' from which the following is an extract:—

[1] As in Northern Sikkim, there are traces in Garhwal of a former glacial age when glaciers extended far down the lower valleys. Himalayan glaciers are for the most part retreating, but some are advancing in Northern Garhwal. One glacier debouching into the Arwa valley has advanced

so far that the valley is in danger of being choked by it. Were it to advance 200 or 300 yards farther the valley stream would be dammed, and as the valley is flat for several miles a large lake would be formed. The bursting of the dam would be disastrous to Badrinath, and other villages in the Alakhnanda valley, and might even result in serious floods far down on the plains. This glacier should be watched.'

This paragraph attracted the attention of the officers of the Public Works Department in the United Provinces, on account of the possible danger involved, by a flood, both to the pilgrims who visit Badrinath, to the various bridges and buildings situated along the pilgrim route, and, in addition, to the head-works of the Upper Ganges canal at Hardwar. The memory of the 10,000 million cubic feet of water which swept down the Alaknanda consequent on the collapse of the landslip dam at Gohna, in 1894, has caused the Government engineers the more certainly to take cognisance of information concerning actual or potential river blockages.

Consequently, at the suggestion of the first writer, a joint inspection of the Arwa valley was made by the authors in June, 1932.

Just prior to their visit, Captain Birnie, a member of the Kamet Expedition, published an account of the Arwa glaciers in the Himalayan Journal.[1] Attached to this account was a map on the scale of half an inch to one mile of the glaciers and peaks at the upper or western end of the Arwa valley. Captain Birnie made no mention of any potential blockage in the Arwa valley, nor did it appear from his map that any of the glaciers marked therein would be likely in the near future to cause trouble. The authors, therefore, expected to find the glacier mentioned by Mr. Smythe lower down the Arwa river in the area to the east of that included in Captain Birnie's map. This proved to be so, and was confirmed on the return of the second author to Calcutta, after an absence of six months, when access could be had to the Geographical Journal, Volume LXXIX (1932). On page 6, Mr. Smythe gives a detailed description of this glacier.

Situation.

The lower part of the Arwa river flows from west to east, joining the Saraswati river near Ghastoli, at Lat. 30° 52′ 30″: Long. 79° 28′, about 10 miles from Badrinath. The area is covered by Survey of India degree sheet No. 53N. The glacier in question occurs about two miles up the Arwa river from its confluence with the Saraswati, and flows

[1] *Himalayan Journal*, Vol. IV, pp. 35-45, (1932).

from the south. The barometric height of the valley bottom at the eastern side of the glacier was 13,720 feet.

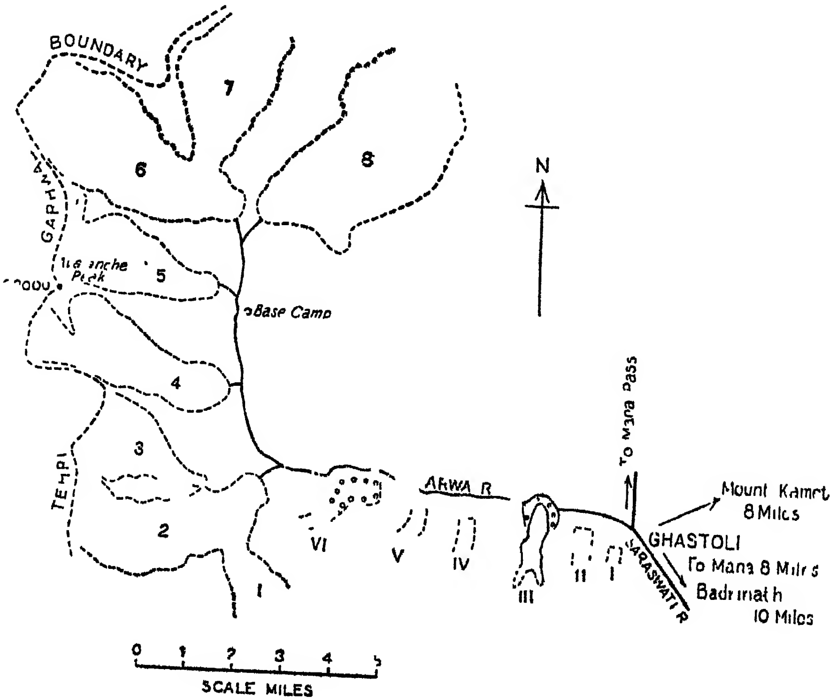


FIG. 1. *Sketch Map of the Arwa glaciers.*

(Glaciers Nos. 1 to 8 are taken from the map in *Geogr. Journ.*, Vol. LXXIX, p. 7. This map differs considerably from that published in Himalayan Journal, Vol. IV, p. 44. Glaciers Nos. I to VI of the lower Arwa valley are approximately marked from notes taken in 1932.)

The authors left Ranikhet by the pilgrim route, *viâ* Dwarahat and Karnaprayag, and reached the glacier on 15th June. Sporadic rain and low cloud hampered their examination, which was completed in three days. On the 19th, they moved camp to height 15,400. The night of the 20th June was spent at the base camp of 16,300 feet, established by the Kamet Expedition in 1931, about 10 miles up from Ghastoli. The authors wish to record their cordial appreciation of the help given by Pandit B. D. Nautiyal, Supervisor.

II.—GENERAL DESCRIPTION OF VALLEYS.

Below Badrinath.

The signs of possible former glacial action below Badrinath are not very definite. At milestone, 172 miles 6 furlongs[1], the granulites are polished, but show no striæ, and remnants of pot holes suggest that the polishing was probably due to river action at a time when the river had not eroded to its present level.

The rock surfaces at mile 175 furlongs 6 are more typical of glacial action, showing the presence of downward-directed striæ. Nevertheless, the shape of the valley here, even allowing for later modification by river erosion, is not at all typical of glacial action. The overlapping spurs in the valley between these two distance marks are definitely a feature characteristic of river rather than of glacial action.

Numerous dip-slope surfaces of the bedded quartz-biotite granulites give deceptive impressions of polishing. These are, however, generally plane and not curved surfaces and are seldom parallel to the sides of the valley.

Above Badrinath.

Looking up the Alaknanda river from the P. W. D. bungalow at Badrinath (Plate 15), there is seen an excellent U-shaped valley, without overlapping spurs, and of simple outline. This was at first taken without hesitation to be of glacial origin. Subsequently, it was seen that to some extent the U-shape was due to the inclination of slopes of talus coming down from the valley sides. The simplicity of the valley course, the width of the valley, and the old moraine-like hummocks upon which the bungalow rests, are, however, strong indications that a glacier formerly descended the Alaknanda at least as far as Badrinath, depositing a terminal moraine there. It is very probable that the original valley was U-shaped, but that it has been later modified by talus to give a secondary U within the primary one. Above the Mana falls, and south of Musapani, are seen old lateral moraines on the west side of the Saraswati river, which have been subsequently slightly dissected by occasional streams flowing from the western slopes. North of Musapani, and also on the west side of the Saraswati, there are small hanging glaciers whose snouts lie some 2,000 feet above the main valley bottom. These send down little moraine. Old moraine below

[1] Miles measured along the pilgrim track from Hardwar. Badrinath is at mile 183.

these glaciers, belonging to the now vanished Saraswati glacier, has been partially covered up by recent talus.

It should be emphasised that there is little purity in the type of rock detritus in any of the valleys visited. Moraine matter interdigitates with talus, while the present river has deposited gravels, with water-rounded boulders, and bedded micaceous silts. The river has often cut into its own deposits, leaving small river-erosion forms within the larger enclosing glacial valley.

Water-rounding of boulders, particularly of biotite-gneiss and tourmaline-granite, is marked, even to within two miles below the debouching of the rivers from the glaciers. Associated with these gravels is angular debris from talus fans and from moraines.

Arwa valley.

On turning from the Saraswati into the east-west Arwa valley there is seen, on the south side, a series of remarkably steep hanging glaciers. No glaciers are seen on the north side, the only noticeable feature being talus fans fed from gulleys in the highly jointed granite. Similar talus fans occur on the south side, alternating and interdigitating with moraines from the hanging glaciers.

Six glaciers occur on the south flank of the valley along its east-west stretch, east of the portion included in Captain Birnie's map. These are given in Roman numerals so as not be confused with those figured by Captain Birnie.

Counting from the east, the snout of No. I glacier lies high up within its hanging valley. That of No. II has descended slightly, but is still about 1,000 feet above the main valley bottom, without any appreciable moraine fan, and need not be further considered. No. III is the glacier with which this report is directly concerned, and will be described in detail in a later section. Seen from the east, at river level (Plate 16), the moraine of this glacier blocks any view of the upstream side of the main valley, having crossed the whole width of the valley except for 778 feet. The snouts of numbers IV and V are high, not having forsaken their lateral hanging valleys. The base of the moraine of No. VI occurs at height 15,000 ft., about 1½ miles east of the snout of combined glaciers, 1, 2 and 3 in Captain Birnie's map, and calls for more comment. Its moraine, like that of No. III, has spread right across the main valley, except for a few hundred feet, and is, indeed, more formidable in appearance than No. III moraine. This moraine, besides being so close to the north side of the valley,

has spread out eastwards down the main valley. On ascending, however, to its hummocky plateau surface, no trace of a glacier could be seen. No sign of ice was visible, except high up in the hanging valley, where it takes a bend to the south-west. The practical absence of falling stones, to be expected from the melting of stone-studded ice, had it been present,[1] and the absence of cracking, usual in ice which is adjusting itself to movement, lead to the supposition that the moraine of No. VI glacier is at present dead, having been forsaken by the retreating ice. The moraine of this glacier is little covered by shrub, grass or lichen, which may be explained partly by the altitude being unfavourable to plant growth, partly perhaps by supposing the retreat of the ice to have been recent. Mr. Smythe (*ibid.*, p. 6) notes 'three glaciers of considerable size debouching into the valley from the south.' In 1932 these glaciers, clearly Nos. IV, V and VI, were not actually debouching into the valley.

On coming to the area included in Captain Birnie's map, the snout of the combined glaciers 1, 2 and 3 was found well to the south of the river fed by the higher glaciers, as indicated on the map. The snout of glacier 4 ends in an ice cave opening out into a small lake a few hundred yards from the river which flows from glaciers 5, 6, 7 and 8, and is only about half a mile from the opposite E. N. E. hillside. On the map, it is shown as over two miles distant from this hillside. This was probably a mistake, the amount of morainic matter at the time doubtless having obscured the snout. This glacier has a relatively low gradient, and it is unlikely that its advance would be rapid. The existence of the very characteristic tan-brown lateral moraine dropped from its north flank[2], some distance in advance of the present snout, rather suggests a retreat. This is, of course, no proof that the glacier may not at the moment be advancing. Even should advance be rapid, the gradient of the N. N. W.—S. S. E. valley, into which it would encroach, is sufficiently steep for any lake formed to be of negligible dimensions.

The remaining glaciers do not concern this report. It may perhaps be remarked that from a position at 17,300 feet, north-east

[1] Very occasionally stones did fall, but the moraine, in its upper part, is made up of stones so precariously tumbled together that such rare falling may be considered to be without significance as an indication of ice.

[2] The rock is a ferruginous micaceous shale; sometimes slate or phyllite.

of the 16,300 foot base camp, glacier 5 was seen to be accurately represented on the map, 6 was recognised, but 8 seems to require some correction.

Secular Changes.

It can be asserted with considerable confidence that a glacier originally descended the Saraswati and Alaknanda valleys as far as Badrinath. Consequently, the retreat of the ice has been great since the period of maximum glaciation.

Little can be said about the recent advance and retreat of the local glaciers in the Arwa valley. The valley is uninhabited, and only the lowest part is used by Bhotiyas as a grazing ground for sheep and goats. No information could be elicited from the Mana Bhotiyas concerning the behaviour of the glaciers. No. III has sometime advanced, and is still active. No. VI, of exactly similar type to No. III, has retreated. No. IV has in no distant past retreated. The collective evidence is therefore contradictory. Accurate measurements of a large number of glaciers over a considerable period are required before any consistency in advance and retreat can be detected.[1]

III.—GLACIER NO. III, ARWA VALLEY.

I. Form.

As previously stated, glacier No. III occurs about two miles up the Arwa valley from its confluence with the Saraswati. It is fed by two very steep, hanging glaciers, which join in a cirque some distance above the conspicuous ice-fall in the constriction at the base of the hanging valley (Plate 18). What may perhaps be called the 'normal' extent of this glacier was doubtless similar to that of Nos. I, II, IV and V, the snout occurring at the constriction, and dropping a moraine in fan form at its base, into the main valley. At the present time, however, the snout has advanced over its moraine so as to rest only 778 feet from the opposite side of the valley at its level (Plate No. 16). The lower part of the glacier, which protrudes beyond the constriction, is inclined northwards at about $11\frac{1}{2}°$. The ice of this lower advanced portion

[1] Such consistency may be found by a study of the 'Rapport pour 1914-28' of the Commission U. G. G. I. des Glaciers.

is so charged with boulders and dirt, and is so effectively covered by moraine matter, that, when first seen from the east, at valley bottom, it was momentarily mistaken for fine-grained laminated sediment interbedded with boulder moraine. The true conditions are best realised from view-points on the northern slopes of the valley, such as D1 or D2, from which radial crevasses and blue ice at the snout are at once evident (Plates 18, 19).

Two features may be stressed:—

(*a*) The ice does not rest on the main valley floor, but on moraine which has been liberated in advance, by tip-heap deposition of boulders, both en-glacial and supra-glacial, from the melting of the snout and sides. The base of the ice is not discernible but, of the 450 feet combined thickness of ice and underlying moraine near the snout, 150 feet may be taken as a fair estimate for the ice, and 300 feet for the moraine.

(*b*) The ice does not, as might have been expected, expand laterally after leaving the constriction, but occurs as a tongue, with roughly parallel sides, and of about the same width as that of the constriction. In this it differs from the ice which must recently have covered the moraine of glacier No. VI.

2. Question of recent advance.

The Survey of India Degree Sheet No. 53N shows, erroneously, a main longitudinal glacier in the Arwa valley terminating three miles up from Ghastoli. Mr. Smythe (*loc. cit.*, p. 6) suggests that the surveyors, looking probably from the east, took glacier No. III to be the snout of a longitudinal glacier in the main Arwa valley. From this it might be concluded that the original advance of glacier No. III occurred before 1864, the date of the commencement of the survey. Since all the side valleys, both to east and west of the Saraswati (Sarsuti) are shown with longitudinal glaciers similar to that in the Arwa valley, it is possible that this explanation does not hold. It is more probable that the surveyors adopted a uniform technique for representing valleys which they had orders not to spend time in visiting; (Dr. Longstaff, *ibid.*, p. 14).

The present condition of the moraine does no more than assign a certain, but not great age, to the original advance beyond the

constriction. It is partly covered with lichen, grass, and shrub. No rates of growth are known for the plants concerned, so that it is impossible to give a quantitative estimate. The grass, and even the shrubs, may be annuals. Lichens, on the other hand, usually grow slowly. Of more value is the density of growth. Only the lateral moraine, on the left or west side of the advanced tongue of ice, is closely covered and gives any impression of age. The greater part of the rest of the moraine is very sparsely covered. Over this latter moraine the ice has dropped boulders of perfectly fresh tourmaline granite[1], completely free from plant growth. These may be seen in Plate 17 as three pale-coloured tongues descending from the ice. Recent advance of the ice is therefore suggested.[2] The moraine immediately at the snout appears to be slightly older than that just at the sides, which indicates that this year there may have been a slight lateral extension of ice near the snout rather than definite longitudinal advance. It cannot be inferred from this that there is no further danger of longitudinal advance. Such signs must mean little more than the capricious behaviour of the glacier in the year of observation. The part of the ice which happened to flow to the snout may, indeed, have been relatively poorly charged with boulders.

No definite indication of advance or retreat is given by the angle of the ice front. This angle varies from 40° to 70° in different parts of the snout. Melting is strong in June. Advance could only be proved if the angle of slope during such a time were vertical. The lack of verticality, on the other hand, does not necessarily indicate retreat, since such a condition may obtain in a glacier which is advancing slowly but at the same time is subject to rapid melting.

3. Modes of future advance.

Two modes of advance may be considered. The first, in which advance is gradual; the second, in which it is sudden and rapid. In considering the first mode of advance it is assumed that the Arwa river, when at its greatest volume, would be capable of dealing with the greater part of the moraine matter which would be tumbled into it. Large boulders might remain scattered in the bed of the

[1] These granites weather very rapidly. The perfect whiteness of a freshly split surface will tarnish within a few months.

[2] The *dak*-coolie of the Kamet expedition reported a slight retreat of the ice, but his evidence may be discounted, since the amount of retreat he figured would not have been sensible to any one except by instrumental observation or cairn sighting.

stream, as some do at the present time, but the smaller boulders would be swept away. Thereby any chance of the micaceous silt, held by the river, being retained by the smaller boulders and pebbles would be prevented. The ice rests on a considerable thickness of moraine, and it is possible to imagine that, in the event of slow advance, in proportion as the river swept the greater part of the toppling moraine away, so would the overlying ice, if at all overhanging, drop as blocks by splitting along crevasse joints. Advance of ice would, it is true, be expected to be most rapid in the early months of the year, when the river is not at its greatest volume. Nevertheless, such advance is, by the first supposition, slow. Whatever slight moraine blockages might occur during the spring along the south side of the river would probably be for the most part removed when the river increased in size and carrying power during the period of melting snows.

The second assumption is that of sudden and rapid advance of ice across the valley.

It is seen from the description that glacier No. III, although gently inclined in its lowest reach, is fed by very steep ice (Plate 18) at a relatively short distance behind the lowest ice-fall. Without wishing to stress the comparison with Kashmir glaciers, it may be considered that the Arwa glacier is of transverse rather than of longitudinal type,[1] one therefore in which a sudden and rapid advance may be expected. The Hassanabad glacier in the Hunza district and the Yengutsa glacier in the Nagir district of Kashmir are typical transverse glaciers and both are rapid movers; Hayden[2] reports the almost incredible distance of six miles in a single year for the advance of the Hassanabad glacier. Glacier No. III, Arwa valley, is, it is true, of very inferior dimensions compared to that at Hassanabad. Nevertheless, even allowing for the difference in scale, it is very probable that the inclination of its feeder glaciers and their closeness to the snout, would permit rapid advance in this Arwa glacier. The short distance of 778 feet which now separates the snout from the opposite side of the Arwa valley could be covered in a single season, when the river was at its lowest. If this were so, the river would at first percolate through the moraine which had been brought so suddenly across its

[1] *Rec. Geol. Surv. Ind.*, XXXV, pp. 125, 136, (1907).

[2] *Ibid.*, p. 135; Mason, *op. cit.*, LXIII, p. 234, (1930), questions the extreme rapidity of this advance, but accepts that in a single year it may have been as much as one mile. Even this is remarkable.

course. Subsequently, however, as the river increased in volume and silt content with the melting of the snows, there would be progressive retention of silt by the moraine, and decreased percolation. A lake would form under these conditions.

It is impossible to state which of these alternatives is the more likely.

4. Magnitude of possible flood.

The largest flood would be produced by the glacier moving rapidly across the gap in the valley. It would, as indicated in Plate 21, form a dam some 400 feet high, but its width would not be great and the materials forming the dam would not be compacted as when a large landslip occurs. Such a dam would probably burst under the weight of water accumulated behind it and, assuming the worst that could happen, the water would just then be coming over the top of the dam.

The length of the lake which would be formed in these circumstances was determined by measuring the distance up the valley to a point which, as closely as could be determined by an Abney level, was at the height of the probable top of the dam. The width of the lake, both at river level and at full lake level, was determined roughly by means of a theodolite. The figures are :--

Length of lake	**7,900 feet.**
Width at full lake level	**1,060 feet.**
Width at river level	**745 feet.**

The valley above the site of the glacier is comparatively flat for about a mile—actual observation showing a rise of 210 feet per mile. From that point, it rises twice as steeply so that the volume of water that would be impounded may be calculated :—

$$\text{Volume} \left\{ 5300 \times \frac{(400+190)}{2} + \frac{(2600\times 190)}{2} \right\} \times \frac{1060+745}{2}$$

$$= 1634,\ 881,\ 500 \text{ cubic feet.}$$

say 1,640 million cubic feet.

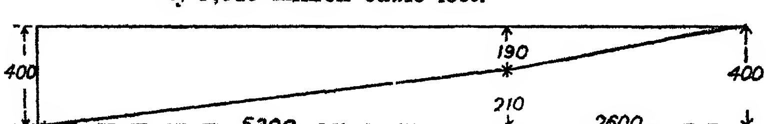


FIG 2.—*Longitudinal section up Atwa valley.*

When the Gohna dam was topped 10,000 million c.ft. of water were liberated in 4½ hours, the upper 380 feet of the dam being washed away during the process. But the Gohna lake was 4 miles long against a length of 1½ miles for the possible lake in the Arwa valley, and it is probable that the Arwa dam will fail under water pressure rather than be topped and scoured out. The Arwa lake would, therefore, be emptied in a much shorter time than 4½ hours, and that time might be fixed at 2¼ hours. This means a discharge of about 200,000 cusecs. in the Arwa valley as against a discharge of 617,284 cusecs. from the Gohna lake. That is to say, the flood from the Arwa lake would have about one third the magnitude of that from the Gohna lake.

On page 16 of the printed report on the Gohna flood [1] are recorded the heights to which the river rose at different places in the Alaknanda valley. The possible Arwa lake would be fifty miles further away from those points and the heights to which the water would rise instead of being one third might be taken as one fourth the heights recorded for the Gohna flood, as indicated in the following table. If the water were to rise to these levels no damage would be done between Chamoli and Hardwar except that the suspension bridge at Karnaprayag would be washed away and small sections of the pilgrim route near Chamoli, Karnaprayag and Rudraprayag would be damaged.

Name of place.	Height (in feet) to which water rose in Gohna flood.	Height (in feet) to which water will rise assuming ¼th the magnitude of Gohna flood.
Chamoli	160	40
Nandprayag	113	28
Karnaprayag	130	33
Rudraprayag	140	35
Srinagar	42	11
Deoprayag	70	18
Biasghat	88	22
Lachmanjhula	35	9
Rikhikesh	18	5
Hardwar	11	3

[1] This report is in the records of the U. P. Government.

Except for a low-lying approach to the suspension bridge at Chamoli and a steel girder bridge over the Alaknanda river in mile 143 furlong 2, the pilgrim route between Chamoli and Joshimath passes many hundreds of feet above the river and is quite out of reach of the anticipated flood.

The steel girder bridge just referred to is constructed in a rocky gorge and has a span of $70\frac{1}{2}$ feet. Assuming a velocity of 30 feet per second for the flood, the rise in water level may be taken as $200{,}000 \div (30 \times 70\frac{1}{2}) = 95$ feet. The bridge is only 64 feet above present water level and would therefore be destroyed.

It is between Badrinath and Vishnuprayag that the maximum damage would be done. There are in this valley two points of constriction, one at Bamini just below Badrinath where there is a steel girder bridge of 84 feet span, and one at Ghursil in mile 179 where there is a steel girder bridge of 40 feet span. The rise in flood level at these points would be :—

Bamini $200{,}000 \div (30 \times 84) =$	80 feet.
Ghursil $200{,}000 \div (30 \times 40) =$	167 feet.

Since the heights of the bridges above present water level are 32 and 60 feet respectively, they would both be destroyed.

There are some low-lying villages between Vishnuprayag and Hanumanchatti and the pilgrim route runs close above the river. Great damage would, therefore, be done both to the villages and to the road.

Much damage would also be done at Badrinath. At one place, opposite the hot spring, the river is only 60 feet wide. Here, the flood would rise to 111 feet, and later, there would be a backing up of water due to a rise of 80 feet at the Bamini bridge. This would mean the submersion of the houses on the river bank and of most of the town. During the flood of August 1931, when the river rose about 30 feet above its ordinary level, one house collapsed and many of the retaining walls on the river bank were washed away. A flood on the scale anticipated would bring down most, if not all, of the houses on the river bank, cut away a large slice of the foreshore, and possibly damage the temple.

Badrinath is built on the terminal moraine of the old glacier mentioned in an earlier section of this report, and the river has cut its way down through this moraine. The left bank is still protected by enormous boulders but the right bank, on which the town

stands, has been deprived of this protection by the activities of builders who have found in the boulders a convenient quarry for building-stone. Quite apart from any danger from abnormal flood, Badrinath needs the protection of a stone embankment and an apron of articulated cement-concrete blocks, else the scour action of the river even in normal annual flood, will gradually undercut and destroy all the buildings on its bank.

5. The probable time for the lake to fill.

On the 22nd June, when the snow-fed rivers were in flood, the discharge of the Arwa stream was found to be about 1,100 cusecs. Since rainfall is scanty, maximum discharge cannot be greater than 1,200 cusecs. As has been suggested, the glacier will probably close the gap in the valley at an early month in the year when the size of the stream is small, and the discharge at that time may safely be taken to be not more than 150 cusecs. Assuming the dam is formed early in March the following figures may be adopted:—

Discharge in March, 150 cusecs. or a total of 402 million c.ft.

Discharge in April, 300 cusecs. or a total of 778 million c.ft.

Discharge in May, 600 cusecs. or a total of 1,607 million c.ft.

Discharge in June, 1,200 cusecs. or a total of 3,110 million c.ft.

Even assuming that half the water is lost through percolation, it will be seen that $\frac{402+778+1607}{2}$ =1,393 million c. ft. of water will have accumulated by the end of May, against a lake capacity of 1,640 million c.ft. On the assumptions made, the lake would be full and the dam would burst on the 3rd June. It is evident that inspections of the glacier should be made as early in May as possible if warnings are to be issued to villages in the danger zone.

It is true, and a remarkable fact, that both the floods in the Alaknanda valley of which there is any record took place in August; the Gohna flood on the 26th August, 1894 and the recent flood, the cause of which has never been precisely ascertained, on the 23rd August, 1931. But the lake area in the Arwa valley is a small one and would fill rapidly, and it is advisable to assume that measures would have to be adopted to issue the necessary warnings much earlier in the year.

6. Mapping.

The moraine and glacier were mapped from a prismatic compass and chain survey and the outlines of the valley and position of the ice falls filled in by obtaining bearings from known points. The results are shown on a scale of 800 feet to the inch in Plate 20.

A cross section of the valley on the axis of the glacier was obtained by reading horizontal and vertical angles on a theodolite from the ends of the base line BC. The cross section is plotted in Plate 21.

Photographs were taken from the points D1, D2, D3 and A.

Fixed points for future observations.

To enable future observers to detect any movement in the snout of the glacier and determine the amount of that movement, two sets of permanent marks were established:—

(*a*) Cairn H was built in such a position that an observer standing with his back against the mark on boulder G looked over Cairn H along a line tangential to the snout of the glacier and parallel (as closely as could be judged) to the granite cliffs opposite. It should be possible to detect any movement in the snout of the glacier by repeating the observation after a fair lapse of time.

(*b*) To allow of a more accurate determination of the movement of the snout its horizontal distance was measured by theodolite from a fixed point F on the opposite cliff. That distance was 778 feet and the angle it subtended at another fixed point E, which is 97 feet away from F, was 32° 5′.

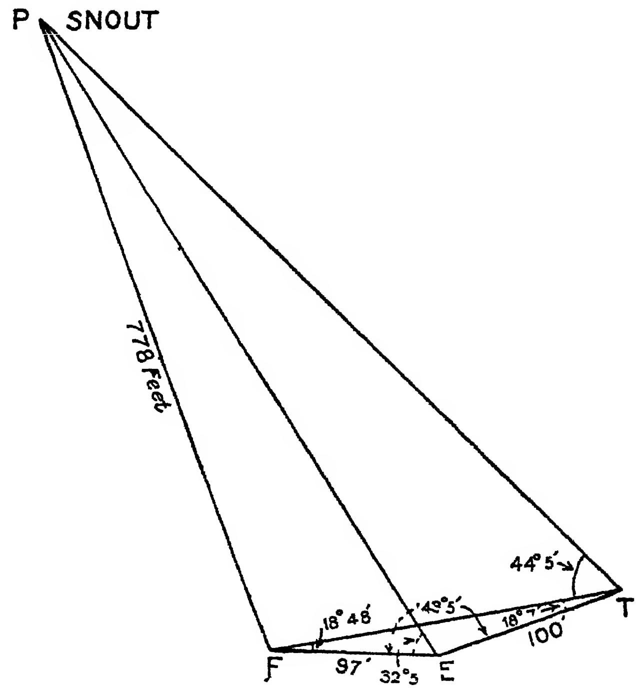


FIG. 3.—*Diagram showing angles, measured in 1932, from fixed stations on to snout.*

The results of these observations are indicated in the sketch given above. E T is a temporary base line (100 feet long) which had to be adopted because it was not possible to set up the theodolite at F. The movement of the snout would be measured by laying down any convenient temporary base line through E and observing horizontal angles as before.

IV.—CONCLUSIONS.

There is no immediate danger of the Arwa valley being blocked and of a lake being formed, but the glacier should be visited every spring for the next five years and the distance of the snout, from the granite cliff opposite, measured in the way indicated in section III (6). Should the glacier move abnormally fast and produce an unexpected blockage, indication of the movement should be obtained in a sudden shrinkage in the stream. Mana Bhotiyas cross the stream on their way up to and down from the pass and a

visit to the glacier will take them only two miles out of their way The authors have asked the Rawal of Badrinath to arrange for the Bhotiyas to go to the glacier should they notice any abnormal shrinkage in the stream.

V.—LIST OF STATIONS.

Station.			Situation.	Position of paint.
A	Theodolite . . . Photograph . . .	Cairn	Bank of river by grass patch.	On top stone.
B	Theodolite . . . . (400′ base line.)	,,	Bank of river . .	Do.
C	Theodolite . . . . (400′ base line.)	,,	Small streamlet . .	Do.
D1	Photograph . . .	Small cairn.	West of large boulder well up on talus.	Do.
D2	Photograph . . .	Cairn	Well up hillside on platform west of gulley.	Do.
D3	Photograph . . .	,,	Well up hillside on inclined platform east of gulley near its bifurcation.	Do.
E	Theodolite		Peg at foot of cliff. .	On cliff-face.
F	Fixed point		....	Do.
G	Tangent to snout .	Large boulder.	....	On vertical east face.
H	Tangent to snout .	Cairn,	On west side of small boulder just above 100 foot bank of river.	On top stone.

LIST OF PLATES.

MGIPC—M—VIII-4-10—6-1-33—850.

Fig. 1. Specimen 1. Cluster of Microspores. (× 300).

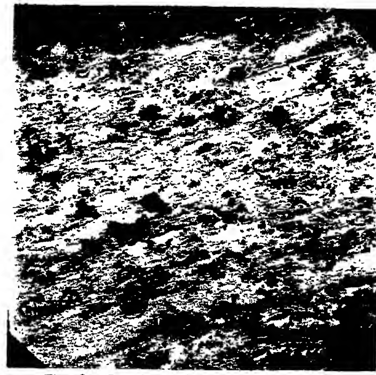


Fig. 2. Specimen 1. Durain. (× 106).

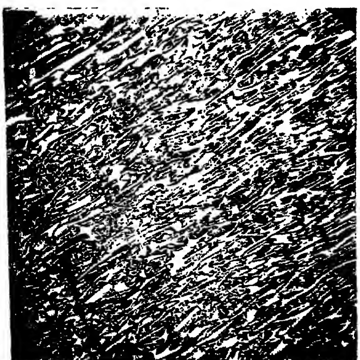


Fig. 3. Specimen 1. Fusain showing 'bogen' structure. (× 106).

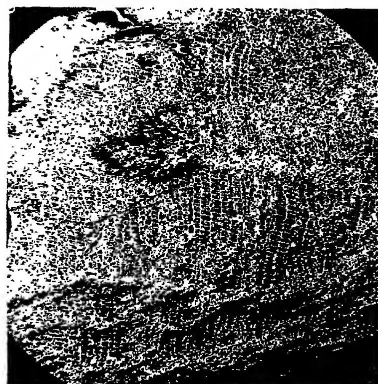


Fig. 4. Specimen 1. Fusain showing cell structure. (× 38).

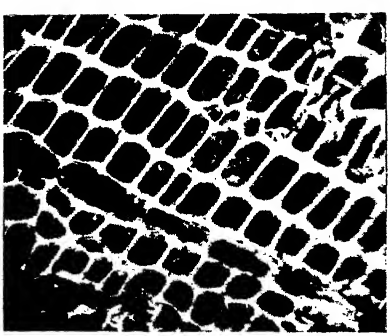


Fig. 5. Specimen 1. Fusain showing cell structure. (× 228).

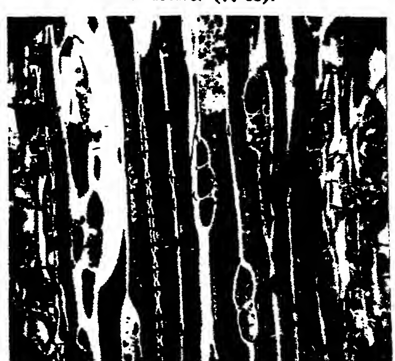


Fig. 6. Specimen 1. Fusain, showing wood ray and bordered pits. (× 228).

THIN AND POLISHED SECTIONS OF INDIAN COALS.

A. K. Banerji, Photomicros. *G. S. I. Calcutta.*

g 1 Specimen 1 Fusain showing thickening
horizontal walls of tracheids (× 106)

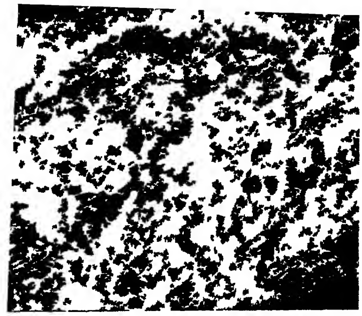


Fig 2 Specimen 1 Durain (× 106)

Fig 3a Specimen 1 Wood showing pluriseriate bordered pits (× 102)

Fig 3*b* Specimen 1 Wood showing uniseriate bordered pits (× 86)

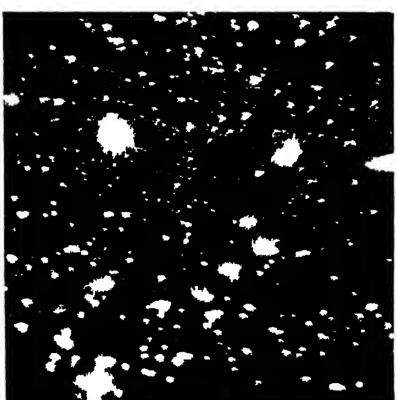


Fig 4 Specimen 2 Section showing fine bands of vitrain (× 65)

Fig 5 Specimen 2 Durain with *Sclerotitis* sp (× 228)

THIN AND POLISHED SECTIONS OF INDIAN COALS

A K Banerji Photomicros *G S I Calcutta*

Records, Vol. LXVI, Pl. 13.

Fig. 1. Specimen 2. Durain with *Sclerotitis* sp. (× 228).

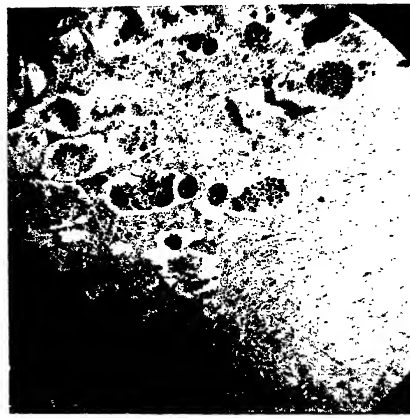


Fig. 2. Specimen 2. Vitrain with *Sclerotitis* sp. (× 78).

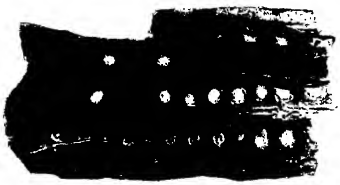


Fig. 3*a*. Specimen 2. Wood showing uniseriate bordered pits. (× 270).

Fig. 3*b*. Specimen 2. Wood showing biseriate bordered pits. (× 270).

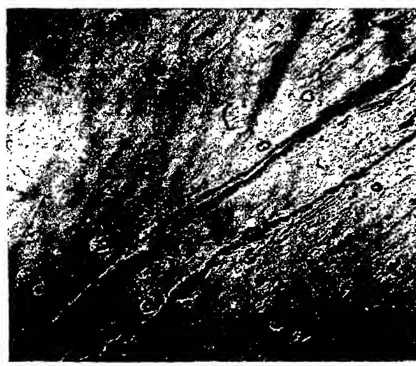


Fig. 4. Specimen 3. Cuticles and grains of pyrite. (× 106).

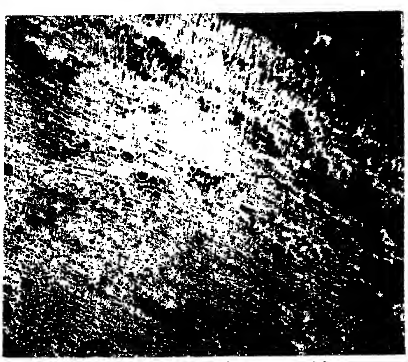


Fig. 5. Specimen 3. *Sclerotitis* sp. and its spores. (× 96).

Fig. 6. Specimen 3. *Sclerotitis* sp. (× 228).

THIN AND POLISHED SECTIONS OF INDIAN COALS.

A. K. Banerji, Photomicros. *G. S. I. Calcutta.*

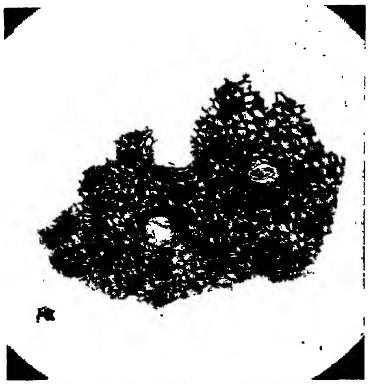


Fig. 1. Specimen 3. Cuticle showing stomatic opening.

Fig. 2. Specimen 4. Section showing cuticle. (× 100).

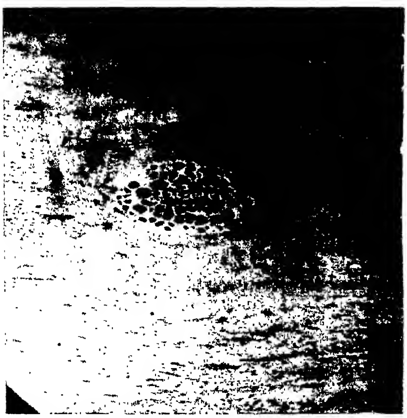


Fig. 3. Specimen 4. *Sclerotitis* sp. (× 228).

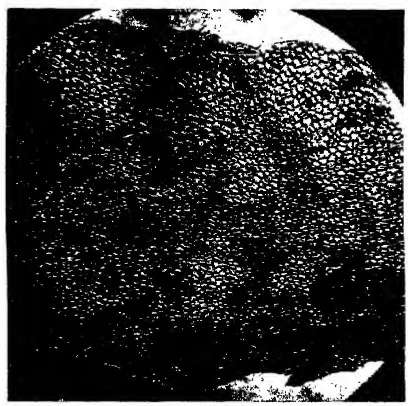


Fig. 4. Specimen 4. Cuticle. (× 100).

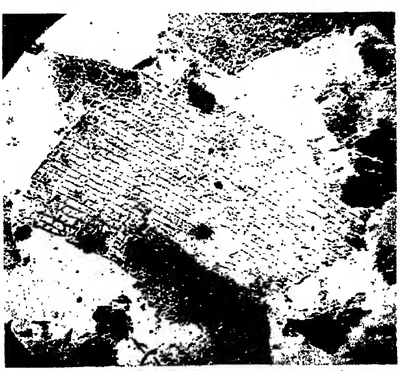


Fig. 5. Specimen 4. Cuticle. (× 100).

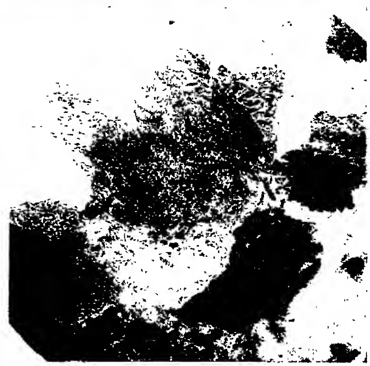


Fig. 6. Specimen 4. Pollen grains. (× 100).

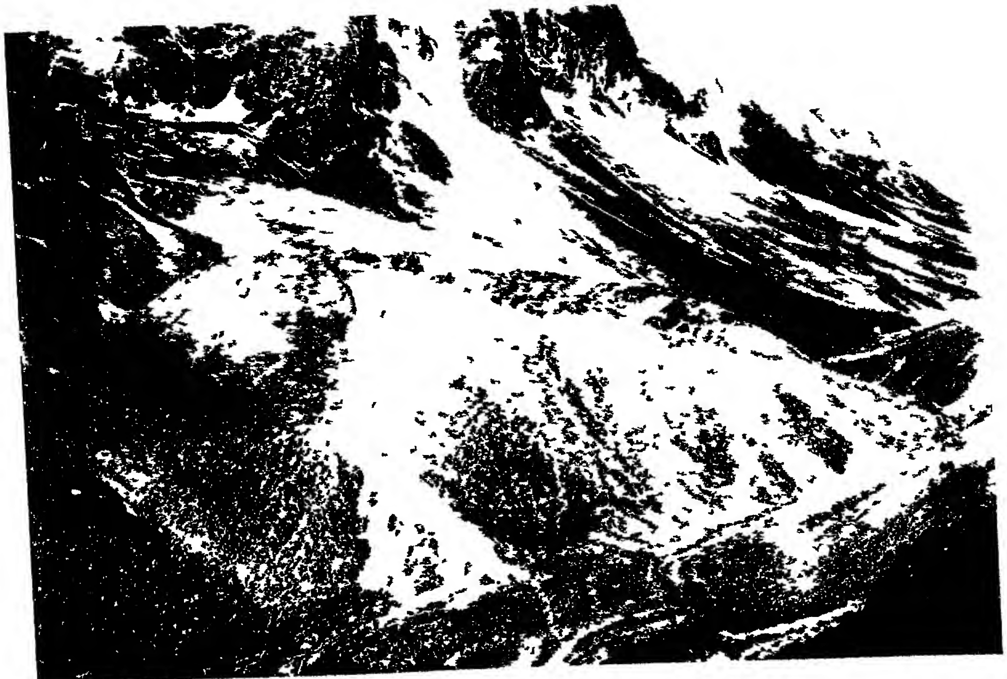
THIN AND POLISHED SECTIONS OF INDIAN COALS.

A. K. Banerji, Photomicros *G. S. I. Calcutta.*

VIEW FROM P. W. D. BUNGALOW, BADRINATH, LOOKING NORTH UP ALAKNANDA RIVER.

J. B. Auden, Photo.

G. S. I. Calcutta.



VIEW FROM STATION D3 FACING 233 GLACIER No III AND ARWA VALLEY THREE TONGUES OF FRESH MORAINE VISIBLE

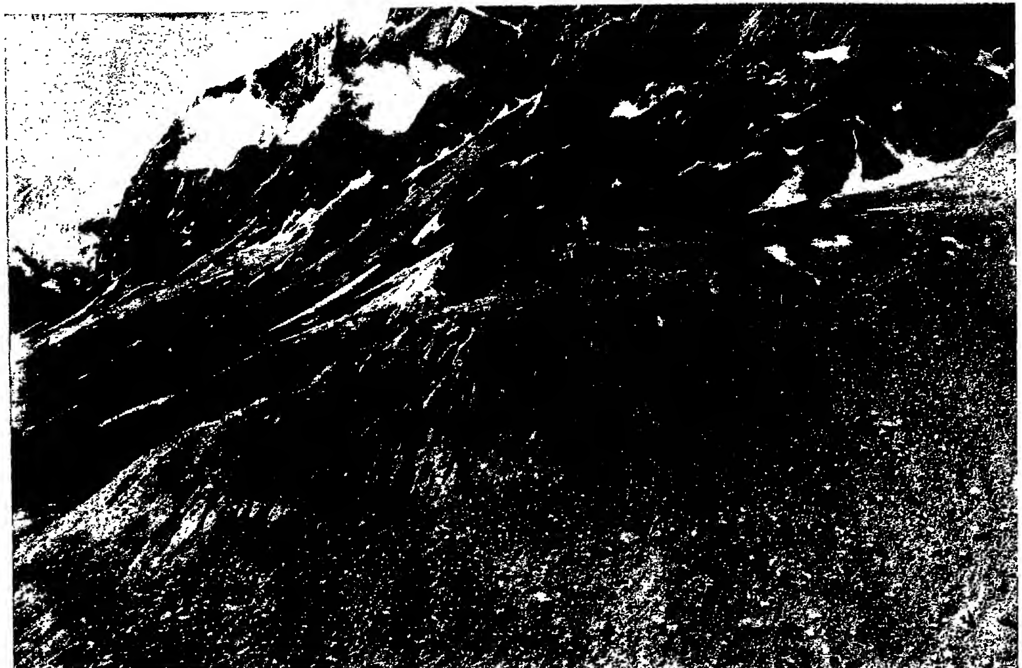
J B Auden, Photo

G S I Calcutta

VIEW FROM STATION D2 FACING 170°. SNOUT, ICE FALL, TWO FEEDING HANGING GLACIERS. GLACIER No. III.

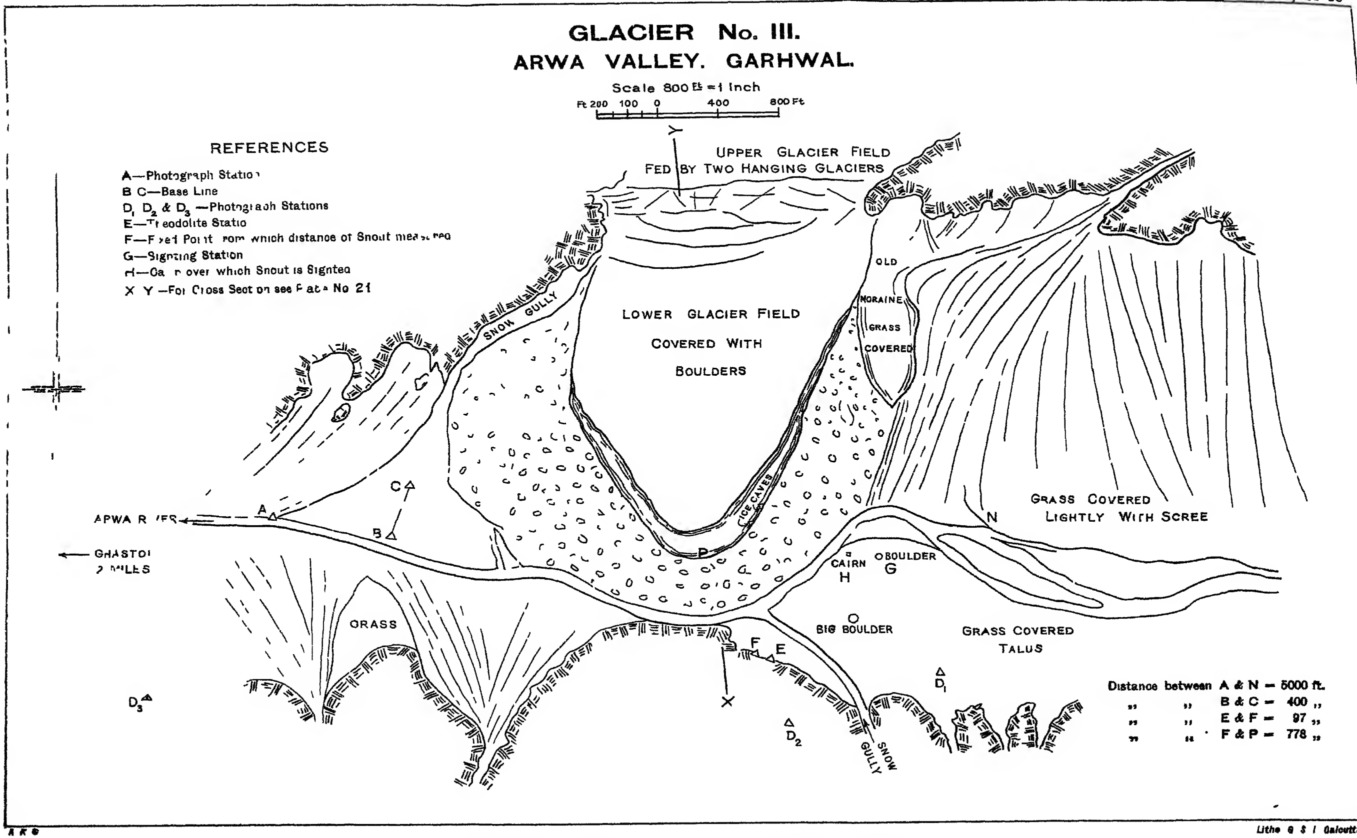
J. B. Auden, Photo.

G. S. I. Calcutta.

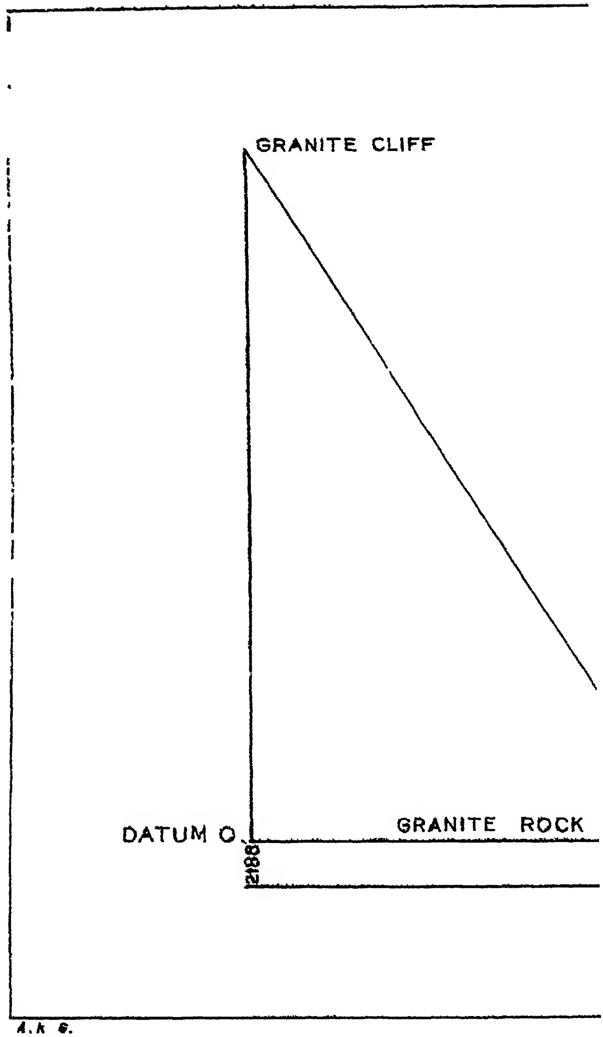


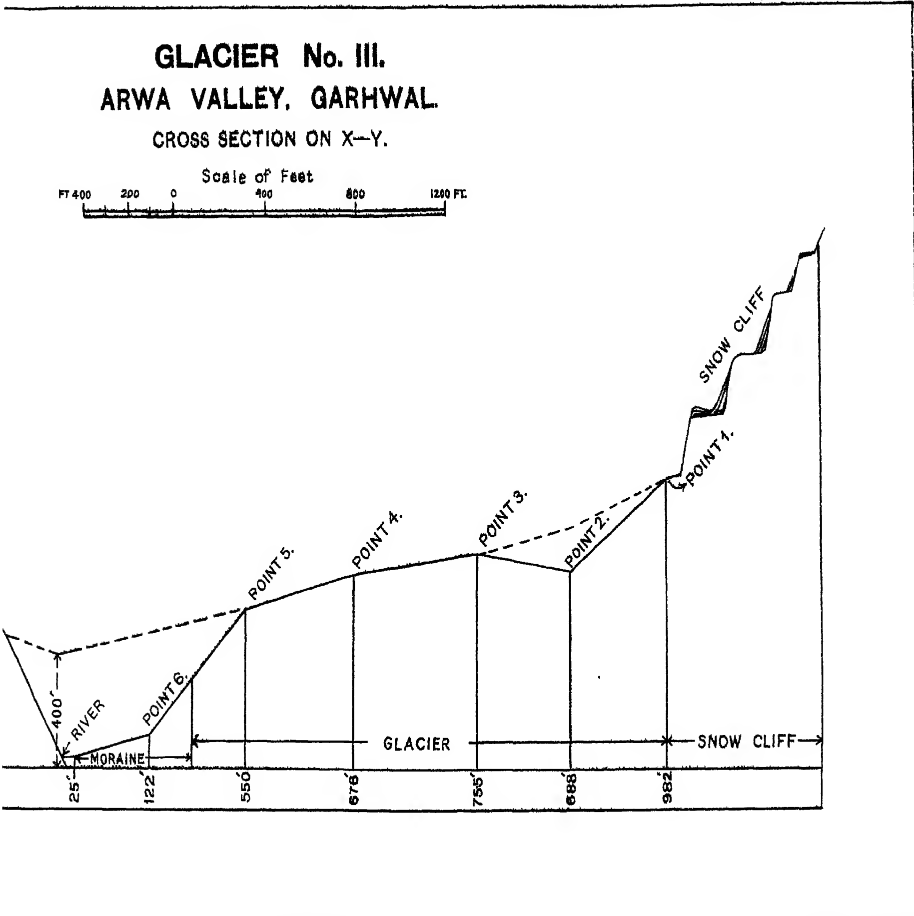
VIEW FROM STATION D1 FACING 138°. GLACIER No. III.

J. B. Auden, Photo *G. S. I. Calcutta.*



See scale above; *for* '100' *read* '200' and *for* '200' *read* '400'.


GRANITE CLIFF
DATUM O.
GRANITE ROCK
2188
A.k G.



Litho. G. S. I. Calcutta.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDI

Part 4.] 1933 [June

STRATIGRAPHIC SIGNIFICANCE OF THE FUSULINIDS OF THE LOWER PRODUCTUS LIMESTONE OF THE SALT RANGE. BY CARL O. DUNBAR, *Professor, Invertebrate Palaeontology, Peabody Museum of Natural History, Yale University.* (With Plate 22.)

INTRODUCTION.

The Salt Range provides a key section for interregional correlation of the Permian formations of Eurasia, but there is still much difference of opinion as to the range of horizons there represented. The brachiopods, which range widely through the section, have not yet given satisfactory results. The ammonites have proved most significant, showing that the Upper Productus Limestone is of late Permian age.[1] But, unfortunately, no ammonites are found in the Lower Productus Limestone. Fusulinids, on the contrary, are very abundant in the latter horizon, but have not been recorded from the higher part of the Salt Range section. Because of the structural complexities in other Permian sections in Asia where the fusulinids have been studied, it has been impossible yet clearly to zone the higher fusulinids for the Permian system as a whole in that

[1] 'Review of the late Paleozoic Formations and Faunas, with special reference to the loc-age of Middle Permian time', *Bull. Geol. Soc. America*, 39, pp. 838-848, (1928).

continent. In the Glass Mountains of Texas and the Delaware and Guadalupe Mountains of New Mexico, however, there is a very complete section of Permian strata about 7,000 feet in thickness and exposed in simple succession. Here ammonites occur at several zones in the lower (Wolfcamp-Leonard) and middle (Word) part of the section, though none, are known from the upper (Capitan) portion. Fusulinids are abundant throughout the entire succession, however, and here they clearly show an evolutional development that can be integrated with that of the ammonites and promises to be very useful in wider correlation.

Dunbar and Skinner[1] have recognised here three new generic types, each represented by a number of species. These genera, based largely on septal evolution, succeed one another in order in the section. The simplest, *Pseudofusulina*, appears with *Schwagerina* in the Wolfcamp formation of Western Texas and ranges up into the Hess-Leonard horizon. In Central Texas, Oklahoma and Kansas, it appears a little below the zone of *Schwagerina* in the horizon of the Foraker limestone and the Stine shale, which is near the top of the Wabaunsee series. At this horizon it is associated with abundant *Triticites*, a genus which is characteristic of the upper half (Missouri group) of our Pennsylvanian system. The genus *Pseudofusulina* is characterised by strongly and regularly fluted septa that join basally at the tips of the folds to subdivide the lower part of the meridional chambers into a series of cell-like chamberlets. The septa touch the floor of the volution, however, except for a median, slit-like aperture. Septal pores are usually common. The species are not very large, rarely attaining a length of 20 mm.

The genus *Parafusulina* makes its appearance in the Hess-Leonard horizon and continues up through the Word, the older genus *Pseudofusulina* meanwhile dropping out in the lower part of the Hess-Leonard horizon. In *Parafusulina* (Pl. 22, fig. 1) the septal evolution has advanced in that the forwardly directed tip of each fold curves far forward and is resorbed distally, leaving an open arch, to the edge of which the backwardly directed fold of the next septum is joined. As a result, each septum possesses basally a regular series of small, semicircular foramina leading from one chamberlet to the next before or aft. It follows that the septa only touch the floor of the volution along the sides of the chamberlets

[1] 'New Fusulinid Genera from the Permian of West Texas', *Am. Jour. Sci.*, XXII, pp. 252-268; Pls. I-III, (1931).

and here they are joined one to the next in such a way as to make a series of continuous basal sutures running round and round the shell in the direction of coiling, a feature to be seen in tangential sections cut just above the floor of the volution. Some of the species of this genus attain enormous dimensions.

The final evolution of these elongate fusulinids is seen in *Polydiexodina*, a genus with septa like those of the preceding genus, but marked by the appearance of a series of slit-like basal apertures corresponding to supplementary tunnels, like the sagittal tunnel, but paired on opposite sides of the latter. This genus also attains a large size and is commonly very slender and elongate. The septa are very numerous, the coiling is compact, and the septal fluting fine.

Judging by the stage of evolution represented by the specimens before me from the Lower Productus Limestone near Warcha, there is no doubt that the horizon is Permian rather than Carboniferous. It should be a little above, though probably not far above, the zone of *Schwagerina*, for the abundant species, '*Fusulina*' *kattaensis*, is a rather primitive representative of the genus *Parafusulina*. It appears that the other forms described from the Lower Productus Limestone, *Fusulina pailensis*, Schwager, and *Fusulina ennearia*, Schwager, if not conspecific, are at least congeneric.

It is noteworthy that while these fusulinids are exceedingly abundant in the Lower Productus Limestone, no large species have been found here. On the other hand, Hayden has described from an undated horizon near Bamian, Afghanistan, an enormous form of fusulinid, which he identified with '*Fusulina elongata*', Shumard, of the Texas Permian. The locality is about 200 or 250 miles west of the Salt Range. There is no doubt that this form is much younger and more advanced than those found in the Lower Productus Limestone. One of Hayden's figures clearly shows a septal evolution at least as advanced as *Parafusulina* and another appears to show the supplementary tunnels of *Polydiexodina*. A restudy of Hayden's specimens would be of great interest.

Still farther to the south-east of the Salt Range, there is another late Permian 'Fusulina Limestone' at Kehsi Mansam, about 40 miles east of Mandalay in Burma. Diener also identified the large species found here with *Fusulina elongata*, Shumard.[1] Unfortunately he

[1] *Pal. Indica*, N. S., Vol. 3, p. 44; Pl. VI, figs. 5*a-e*, (1911).

did not describe the species, but his sections, indicate a species of *Polydiexodina*.

It may be inferred, therefore, that there is a widespread horizon of late Permian Fusulina Limestone in southern Asia marked by the genus *Polydiexodina* and approximately concurrent with the Upper Delaware-Capitan horizon of the American Permian. It should be expected in the Upper Productus Limestone, which has thus far yielded no fusulinids.

The greatest present need is for a critical restudy and adequate description of all the large fusulinids of the Himalayan region. Toward this end we introduce here a redescription of the common Lower Productus Limestone species, '*Fusulina*' *kattaensis*, Schwager.

We wish to express our cordial thanks to the Director of the Geological Survey of India for supplying us with the splendid material used in the study of this species.

REDESCRIPTION OF *PARAFUSULINA KATTAENSIS* (SCHWAGER).

Plate 22, figs. 1-2j.

Fusulina kattaensis, Schwager, *Pal. Ind.*, Vol. I, p. 985; Pl. CXXVI, figs. 1-11; Pl. CXXVIII, fig. 4, (1887).

Description.

This rather small, subcylindrical species develops five to six volutions and rarely attains a length of 14 mm., though 10 to 12 mm. is more usual. The ends of the shell are usually bluntly rounded, tending to become subtruncate at maturity. The middle of the shell is generally a little thicker than the rest, the axial profile being a much elongated ellipse, but occasional specimens are scarcely at all inflated at the centre. The axis is normally straight.

The rate of expansion in the sagittal plane is fairly constant and is represented by the following figures showing the height (in microns) of successive volutions:

	Proloculum.	1st.	2nd.	3rd.	4th.	5th.
Specimen A .	240	70	140	190	220	280
Specimen B .	240	65	155	180	215	280
Specimen C .	200	100	140	220	240	270

The length, on the contrary, varies rather greatly. It is normally a little over four times the thickness in adult shells, but in occasional specimens rises to five or six times the thickness. The most elongate shells appear decidedly cylindrical and the shortest ones sausage-shaped. If the extremes were isolated they would appear to be distinct species, but the vast majority of specimens are intermediate in length and show complete gradation. Other characters also confirm the conclusion that we are dealing with a single species. For example, specimen A of the table given above has a length of 14·0 mm. and specimen B of only 11·5 mm. Yet they have identically the same diameter, the same number of whorls, same size proloculum, same rate of expansion and same sized tunnels.

The proloculum is rather large, irregular in shape and very thin-walled. Our measurements indicate a diameter ranging from about 200 to 360 microns. The wall of the first volution is very thin and the form of the shell at this stage is commonly difficult to determine. The second volution is elongate-fusiform and 3·25 to 5 times as long as thick. The ratio of length to thickness normally increases gradually in later volutions as shown by the following measurements:

Specimens.	1	2	3	4	5	6
Volution 1 .	3·+ : 1	3· : 1	..	3· : 1	3·1 : 1	3·6 : 1
Volution 2 .	3·5 : 1	3·7 : 1	3·5 : 1	3·5 : 1	3·3 : 1	5· : 1
Volution 3 .	3·25 : 1	4·+ : 1	4· : 1	4·2 : 1	4· : 1	6· : 1
Volution 4 .	4· : 1	4·5 : 1	4·25 : 1	4·4 : 1	4 + : 1	6· : 1
Volution 5 .	4·+ : 1	4·5 : 1	5 : 1	4·5 : 1	4·5 : 1	6· : 1

The wall attains a thickness of 50 to 60 microns in the second volution, increases to 60 or 70 in the third, 70 to 90 in the fourth and rarely attains to 100 in the fifth. It is generally thickest in the penultimate whorl. The keriotheca is moderately coarse, 20 to 25 alveoli occupying a space of 500 microns.

The septa are intensely and regularly fluted, though the folding affects chiefly the lower half of the septum. The folds of successive septa unite basally to subdivide the lower part of each meridional chamber into a series of regular cell-like chamberlets which are well seen in etched specimens or tangential polished surfaces like that of figure 2e of Plate 22. In such sections the chamberlets present a striking uniformity, ten of them occupying a space of about 2·5 mm. In the outer volutions the basal tip of each forwardly directed fold curves forward into a plane parallel to the floor of the volution, meeting the backwardly directed fold of the next septum

to form an open arch or foramen from one chamberlet into the next. As a result of this growth the septa join the floor of the volution only along the lateral sides of the chamberlets, where they are joined, one to the next, to form basal sutures running round the shell in the direction of coiling. This feature is best seen in polished tangential surfaces cut barely above the base of a volution as in figure 2e. Figure 2c is not cut quite deep enough. The septal arches appear in axial sections as a regular series of small, semicircular foramina along the base of the septa. They can be seen in thin sections but are more certainly identified in polished surfaces like figure 2g, in which every septal fold shows one of the foramina. It must not be supposed that these openings are due merely to truncation of the tips of the folds by the plane of the cut, for when the matrix is transparent the foramina can also be seen in the opposite folds which recede from the polished surface. The tangential surfaces like that of figure 2e are the final proof, however, that the septa do not reach the floor at the front or back of a septal fold.

The meridional tunnel is well-defined and rather wide, the tunnel angle ranging generally between 50° and 60° in the outer volutions, but it is commonly between 40° and 50' in the first three whorls. The apertures are broadly elliptical and nearly as high as the volution. No septal pores have been observed. The septal count in three representative specimens is as follows:—

Volutions.	1	2	3	4	5	6
Specimen 1 .	8	15	20	17	24	28
Specimen 2 .	7	14	17	22	22	30
Specimen 3 .	12	19	27	28	..	..

Discussion.

Schwager's types of *Fusulina kattaensis* were derived from 'the Upper region of the Lower Productus Limestone at Katta'. Other specimens occurring lower in the formation at Katta he thought might prove to be a distinct variety but because they were generally more or less crushed, he was unable to make a satisfactory comparison, noting merely that in the lower form 'both ends are generally more paraboloid in their outline, whilst they are more abbreviated in the typical form. Also the increase of the whorls is a different one.'

The abundant material before us from Warcha is from two horizons, one at the base of the Lower Productus Limestone and the other about 50 feet higher. Both contain the same species, which seems to be the typical form of *F. kattaensis.* At least, it is not possible from Schwager's incomplete description of the species to point out any differences from the Warcha form.

There is a striking resemblance to *F. longissima*, Möller, which has nearly the same size and proportions, possesses the same number of volutions, and has an equally large and irregular proloculum; but the Russian species has a much thinner wall and a narrower tunnel, its slit-like apertures having according to Möller, only one-fifteenth to one-eleventh the length of the corresponding volution, whereas in *F. kattaensis* it is, according to Schwager, about one-ninth. The specimens before us show considerable variation in this regard, but in the outer whorls, at least, usually have the aperture between one-eighth and one-twelfth the length of the volution.

The exact nature of *Fusulina pailensis*, Schwager, and its relation to *F. kattaensis* are still obscure. Schwager's description is inadequate in many respects and unfortunately includes serious discrepancies between text and illustrations. The types of the two species were from different geographic localities, but the horizon appears to have been about the same.

Schwager stated (p. 987) that *F. pailensis* is characterised by an 'extraordinarily small embryonal chamber', and that by this character it can be easily distinguished from *F. kattaensis.* But the resemblances between the two species are so close that he finally concluded his description of *F. pailensis* with the statement that the species cannot as yet be considered as fully established as long as its geological relations to *Fus. kattaensis* on the one hand and *Fus. longissima* on the other are not yet quite distinctly made out. According to Schwager's statement in the text, *F. pailensis* is an extremely slender species with a normal length of 13 mm. and a diameter of 1·7 mm., the ratio of length to breadth being, thus, approximately 8 to 1; but the several figures of the species on his Plate CXXVII indicate a ratio of about 4·4 to 1 or a little less. This is almost exactly the ratio shown for *F. kattaensis.* As calculated from Schwager's enlarged figures, the diameter of the proloculum in three of the types of *F. pailensis* measures 112, 140, and 114 microns, respectively, whereas it measures 256 microns in one of

the types of *F. kattaensis*, 250 × 210 in another, and 256 × 200 in a third.

The collections sent us by the Geological Survey of India did not include material from the vicinity of Pail. However, Professor von Huene has kindly loaned a specimen of the Fusulina Limestone from the Koken collection at Tübingen, which was secured at Pail. The stone is so hard that specimens cannot be freed and well-oriented sections are difficult to secure. This fact recalls Schwager's remarks on the occurrence of *F. pailensis*. The sections before us differ from Schwager's types, however, in having proloculi of large size, five specimens measuring 260, 360, 310, 370 and 400 microns, respectively. This accords well with the range of size in *F. kattaensis*. There is essential agreement with the latter species also in ratio of length to thickness, in number of volutions, and rate of expansion in the sagittal plane. There is further similarity in the septal count. The tunnel angle in these specimens ranges from 30° to 40° in the third volution, but widens to 40° to 50° in the fourth and as much as 60° in the fifth, thus agreeing with *F. kattaensis*. The septal evolution appears to be slightly less advanced in the Pail specimens than in those from the Wardha region, barely passing from the *Pseudofusulina* to the *Parafusulina* stage in the adult volutions.

It appears evident, therefore, that the specimens before us from Pail agree much more closely with Schwager's description of *F. kattaensis* than with that of *F. pailensis*. Probably Schwager's types came from a different zone at Pail. More material is needed for study before it will be possible to demonstrate the relation of the shells represented in the Koken collection to *P. kattaensis*.

EXPLANATION OF PLATE.

PLATE 22, FIG. 1.—*Parafusulina wordensis*, Dunbar and Skinner. A fragment of a silicified cotype from the Word formation of the Glass Mountains, West Texas, to show the character of the septa in *Parafusulina*. The septa are partly broken away. Fragments of the roof of the outer volution may be seen at A, the upper margins of the septa at B, septal arches at C and the basal sutures running round the shell at D (× 16½).

FIG. 2a.—*Parafusulina kattaensis* (Schwager). A specimen more fusiform than the average or typical shape.

FIG. 2b.—Antetheccal view of a submature specimen showing the regular septal fluting.

FIG. 2c.—A specimen more elongate than the typical form, polished down to a tangential surface just above the floor of the outer volution, showing how the chamberlets communicate fore and aft as the basal sutures of the septa run around the shell. Outside the mid-length of each half the septal arches lie below the plane of the section.

FIG. 2d.—Axial section of a typical specimen. Note the prolocular foramen with its invaginated ' bottle-neck '.

FIG. 2e.—An exceptionally short shell polished off to a tangential surface showing the regular cell-like chamberlets. The section only cuts deep enough to cut the septal arches next besides the tunnel.

FIG. 2f.—Axial section of a large elongate specimen, showing the basal foramina in each septal fold.

FIGS. 2g and h.—Axial surface and external view of a very large, subcylindrical specimen. The basal foramina and the tunnel are conspicuous.

FIGS. 2i and j.—Sagittal sections of two representative specimens.

All from zone 50 feet above the lowest Fusulina Limestone at the base of the Lower Productus Limestone in a stream section about two miles N. N. E. of Rukhla, near Warcha, Salt Range, India. Geological Survey of India Collection K25/498 (all figures × 8).

DADOXYLON ZALESSKYI, A NEW SPECIES OF CORDAITEAN TREES FROM THE LOWER GONDWANAS OF INDIA. BY B. SAHNI, M.A., SC.D., D.SC., F.G.S., F.A.S.B., *Professor of Botany, University of Lucknow.* (With Plates 23 and 24.)

INTRODUCTION.

Under the name *Dadoxylon zalesskyi*,[1] it is proposed to describe a block of silicified wood recently found near Asansol, in the Raniganj coalfield, Bengal (Pl. 23, fig. 1). In this region quantities of fossil wood have been found in recent years, including some large tree trunks.[2] In the great majority of specimens only the secondary wood has been found preserved, the pith and primary wood being either badly crushed or too deeply situated to be available for study in thin sections. For these reasons none of the specimens so far mentioned in the literature have been specifically determined. This is possible in the specimen now described, in which the pith and primary wood are fairly well preserved.

I wish to express my sincere thanks to Professor K. K. Mathur of Benares University for the loan of the material for investigation, and to Prof. Seward for kindly criticising the manuscript of this paper. The sections here described were prepared by my assistants, Messrs. Shanker and Ram Singh Sharma.

OCCURRENCE OF FOSSIL GYMNOSPERMOUS WOOD IN THE RANIGANJ AREA.

Fossil wood has long been known to occur in the Raniganj coalfield, but no adequate description has ever been published. In 1882, Schenk[3] briefly described under the name *Araucarioxylon robertianum* a fragment of wood collected long ago by the brothers

[1] This name was suggested before I had seen Arnold's recent papers (*see* Bibliography) on the related genus *Callixylon*, of which he has named one new species *C. zalesskyi*.

[2] *See* Bradshaw, E. J., and Sahni, B., *Rec. Geol. Surv. Ind.*, LVIII, Pt. 1, (1925); Fox, C. S., *Rec. Geol. Surv. Ind.*, LX, Pl. 30, (1928).

[3] Schenk, 'Die von den Gebrüdern Schlagintweit in Indien gesammelten fossilen Hölzer', *Engl. Bot. Jahrb.*, III, p. 335, (1882).

Schlagintweit near Asansol. During recent years, several large tree-trunks and many loose fragments of silicified wood have been discovered in the Raniganj coalfield. The largest of these specimens, originally about 93 feet in length, was unearthed in 1924 at the Kumarpur cutting of the East Indian Railway, about two miles west of Asansol station (Bengal). This magnificent fossil is now preserved at the Indian Museum, Calcutta.[1] One of the smaller trees is now in the museum at Patna (Bihar). In January, 1928, a party from the Botanical Department of the Lucknow University excavated about ten feet of another tree, embedded obliquely in the sand near the same cutting; an unknown length, representing the thicker proximal part of the tree, being left *in situ* as it was too deep to be extricated at the time.

With the exception of the Schlagintweit specimen, which I have not seen, there is nothing in the gross features of these specimens, nor in their anatomy so far as this is known,[2] to suggest that more than one species is represented. The appearance, colour, mode of preservation and the distribution and shape of the branch-scars are identical; well marked growth-rings are present in all. The specimens show all the signs of drift wood. Their poor preservation shows that decay had started before petrifaction set in. There is no trace of bark or of roots. None of the smaller branches are preserved, although their scars are seen in large numbers. The identity in external characters in so many fragments, scattered over an area of several square miles, lends support to the idea that the trees belonged to one species and must have grown in great abundance.

GEOLOGICAL AGE.

The fossil tree-trunks found near Asansol in 1923 and 1924 were considered by Mr. E. J. Bradshaw to belong to the Panchet series, which is correlated with the Trias of Europe.[3] But from the recent work of the Coalfields Party of the Geological Survey of India (including the late Rao Bahadur S. Sethu Rama Rao, and Messrs. E. R. Gee, A. K. Banerji and J. B. Auden, under the superintend-

[1] *See* Bradshaw and Sahni, *op. cit.*, (1925), for a photograph and brief description.

[2] I have examined about a dozen thin sections, taken from at least three different individuals.

[3] *See* Bradshaw, E. J., and Sahni, B., *op. cit.*, p. 77, (1925).

ence of Dr. C. S. Fox), it appears that the fossils belong to the underlying Raniganj series and are, therefore, more correctly assigned to the Upper Permian.[1] The late Rao Bahadur S. Sethu Rama Rao found, during his work south of the Damuda river, a well marked sandstone bed containing an abundance of fossil wood near the top of the Raniganj series; and Messrs. Gee and Banerjee traced this horizon to the Kumarpur cutting, where the type-specimen of *D. zalesskyi* was discovered, not far from the big tree briefly described in 1925. The observations of Messrs Gee and Banerji, that the fossil-wood sandstone is separated by a slight unconformity from the Panchet beds, and should therefore be assigned to the Raniganj series, has been confirmed by Dr. C. S. Fox, who has named the horizon the Kumarpur (fossil-wood) sandstone. As Dr. Fox justly observes, the palæontological evidence points more to a palæozoic than to a Mesozoic age for the sandstone; and I may add that the majority of the species with which *D. zalesskyi* has been compared (*vide infra*) come from strata which are generally regarded as Permian.

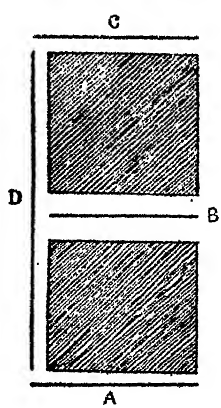


FIG. 1.—Diagram to show how the central core of the main axis taken out from the type-specimen was sectioned. A, B, C are transverse sections from below upwards. D is a longitudinal section. (nat. size).

[1] *See* Fox, C. S., *op. cit.*, p. 365, (1928); Pascoe, E. H., *Rec. Geol. Surv. Ind.*, LXI, p. 119, (1928); Fox, C. S., *Mem. Geol. Surv. Ind.*, LVIII, p. 142, (1931); Gee, E. R., *Mem. Geol. Surv. Ind.*, LXI, pp. 54, 109, 207, (1932).

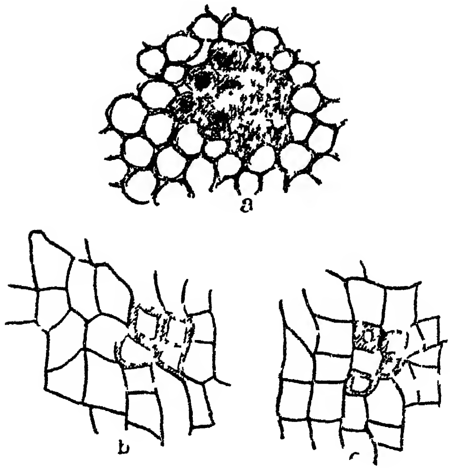


FIG. 2.—Sclerotic nests in the pith (type-specimen), *a* in cross-section of branch. *b*, *c* in longitudinal section of branch. (× 80).

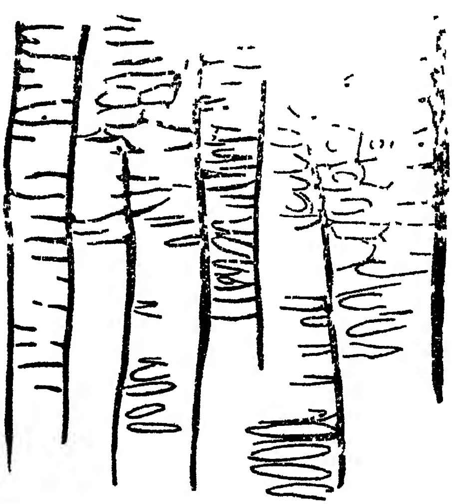


FIG. 3.—Part of the primary wood (branch of type-specimen) showing transition from scalariform to pitted tracheids. (× 750).

DESCRIPTION.

The type-specimen (Pl. 23, fig. 1) agrees with the southern species of *Dadoxylon* in having sharply marked growth-rings, in

its cylindrical pith, and in the fact that the bordered pits on the tracheids are frequently uniseriate, separate and rounded.

Sections were cut from one of the branch-scars and from the central core of the main axis (*see* Fig. 1, p. 416). The structure of the pith and primary wood is better preserved in the branch, that of the secondary wood is better shown in the main axis. In the branch there is a pith 7 to 8 mm. wide (Pl. 23, figs. 2, 3) consisting of large parenchymatous cells arranged in vertical rows (Pl. 23, fig. 5; Pl. 24, fig. 3). Groups of isodiametric stone-cells, and sometimes isolated stone cells, lie scattered among the parenchyma (Pl. 24, fig. 1; Fig. 2, p. 417). In the thick walls of these cells concentric layers of growth as well as pit-canals are sometimes clearly seen. There is no peripheral zone of transfusion tissue such as Miss Holden[1] described in *D. indicum*. Traversing some parts of the pith irregularly are seen a number of irregular spaces (Pl. 24, fig. 1) which at first sight may be mistaken for secretory canals. But they are no doubt due to decay before petrifaction; they are not seen in the best preserved parts of the pith (*see* Pl. 23, fig. 5, bottom left).

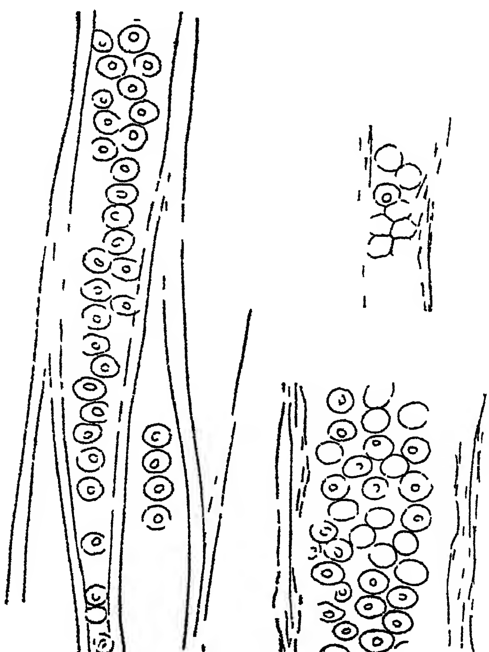


FIG. 4.—Bordered pits from type-specimen (Section D). (× 350).

[1] Holden, R., *Ann. Bot.*, XXXI, pp. 315-326, (1916).

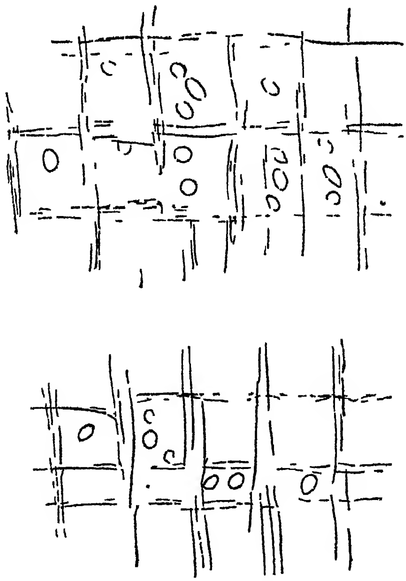


FIG. 5.—Pits in the field (type-specimen). (× 350).

In the main axis the pith has been crushed and divided longitudinally into two parallel halves. The structure is the same as in the branch, but the preservation is indifferent (Pl. 23, fig. 4).

The points of departure of the leaf-traces are marked by small projections of the pith encroaching upon the woody cylinder (Pl. 23, fig. 4). The leaf-trace at its origin is a single wedge-shaped endarch bundle; whether it divides in its course through the secondary wood cannot be ascertained from the available sections.

The primary wood zone is at most a dozen cells wide, the metaxylem elements being rather wider in the radial than in the tangential direction (Pl. 23, fig. 4; Pl. 24, fig. 1). The secondary wood lies immediately in contact with the primary, the tracheids being squarish, and more regularly arranged. The protoxylem is endarch, without any admixture of parenchyma such as Miss Holden described in the nodal region in *D. indicum*. The tracheids of the protoxylem and primary metaxylem show bar thickenings varying from annular or scalariform to reticulate as we pass outwards (Fig. 3). Spiral elements have not been observed, but this is probably due to the preservation.

In the secondary wood the pits are usually round or elliptic and either separate or contiguous, but sometimes they are flattened into hexagons (Pl. 24, fig. 4; Fig. 4). The narrower cells

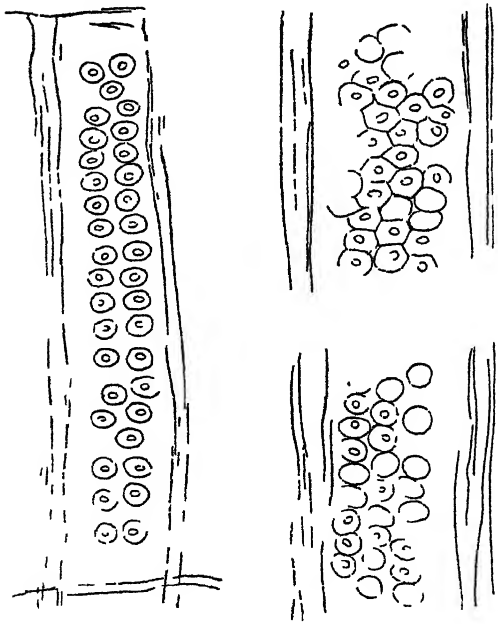


FIG. 6.—Bordered pits from small tree found south of Kumarpur cutting, for comparison with type-specimen. (× 350).

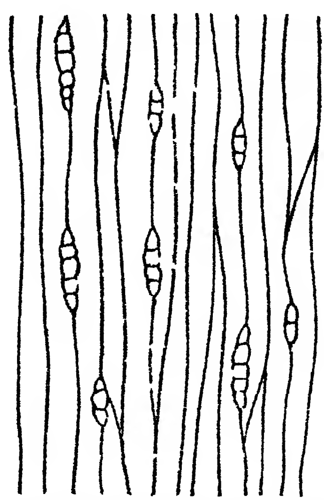


FIG. 7.—Tangential section from the same tree. (× 120).

show one or two rows of pits, the arrangement in the latter case being alternate or sub-opposite; in the wider elements the pits may be in four or five alternating rows. The border averages 10·5μ in diameter, the pore is rather large and circular or broadly elliptic.

The medullary rays are very numerous, all uniseriate and rather low; as a rule only three to five cells high, they seldom exceed ten cells in height. The cells as seen in radial sections are several times as long as high, each cell spanning two to four tracheids (Pl. 24, fig. 5). The horizontal and tangential walls appear smooth but this may be due to bad preservation. In each 'field' there are a few (one to three or four) oval or circular pits devoid of a border (Pl. 24, fig. 5; Fig. 5).

Locality.—Between telegraph posts 133/18 and 133/19, about two miles west of Asansol (East Indian Railway), Bengal. Collected by Mr. K. P. Sinha, formerly of the Geological Department, Benares Hindu University, in July, 1926.

Horizon.- Kumarpur sandstone (=top of the Raniganj series, Lower Gondwanas), homotaxial with the Upper Permian of Europe.

Type-specimen at the Geological Department, Benares Hindu University. Fragments and thin sections in the author's collection and in the collection of the Geological Survey of India, Calcutta, (Reg. No. 15168).

OTHER SPECIMENS PROVISIONALLY REFERRED TO *D. ZALESSKYI.*

Till the pith and primary xylem have been examined the other specimens cannot be definitely referred to this species, but the external appearance and the structure of the secondary wood is identical. The big tree found in 1924 and now in the Indian Museum, Calcutta, was very badly preserved. In the sections briefly described in 1925,[1] pits of the hexagonal type only were then observed but the only spots where bordered pits were at all discernible were a few minute specks which just gave an indication of the pitting. The type-specimen was found very near the big tree and might easily pass for a branch of it.

The small trunk, about seven feet long, discovered just south of the Kumarpur cutting, is also preserved in Calcutta. Sections from a fragment of this specimen are figured in Plate 24, figure 6, and in Figures 6 and 7 on page 420; they show that the structure of

[1] Bradshaw, E. J., and Sahni, B., *op. cit.*, p. 77, (1925).

to secondary wood is identical with that of the type-specimen. Nothing is yet known of the pith and primary xylem.

The large tree now in the museum at Patna has not yet been examined in thin sections, but there is no reason to believe that it belongs to a different species. The tree figured by Dr. Fox in 1928[1] also presumably belongs to the same species.

COMPARISON WITH *ARAUCARIOXYLON ROBERTIANUM*, SCHENK.

Under the name *A. robertianum*, Schenk united four different specimens of unknown geological age, which came from such widely separated localities as Asansol in Eastern India, Mangali in the Central Provinces, and Travancore in the extreme south. The pith and primary wood were not preserved in any of the specimens, this alone would make specific or even generic determination difficult. Schenk's brief description was based upon the best-preserved of the four specimens but unfortunately this specimen was not specified. I have elsewhere[2] given reasons for the view that *A. robertianum* probably included two or more species or even genera. It is possible that Schenk's Asansol specimen belonged to *D. zalesskyi*, but it seems certain that his description of *A. robertianum* was not based upon it, because he describes medullary rays commonly 24 cells and sometimes exceeding 40 cells in height, while in *D. zalesskyi* they were very much lower.

COMPARISON WITH OTHER DADOXYLA FROM GONDWANA-LAND; *DADOXYLON KRAEUSELI*, SP. NOV.

While *D. zalesskyi* shows clear affinities with the Dadoxyla characteristic of the southern flora, it is not referable to any of the known types. In the possession of sclerotic cells in the pith, it differs from all the known southern species and resembles the Siberian *Mesopitys tchihatcheffi*. Of the two known Indian species, *D. indicum*, Holden,[3] is at once distinguished by its perimedullary zone of transfusion tissue, by the presence of parenchyma in the protoxylems (in the nodal region) and by the fact that the radial pits are contiguous and only in one or two rows. Of the other species

[1] Fox, C. S., *op. cit.*, Pl. 30, (1928).
[2] Sahni, B., *Rec. Geol. Surv. Ind.*, LXV, p. 442, (1931).
[3] Holden, R., *op. cit.*, p. 315, (1916).

D. bengalense,[1] only the secondary wood is known, but this is quite distinct, the bordered pits being unusually small (average diameter, 4μ) and grouped in a manner somewhat recalling *Callixylon*.

The Falkland wood, *D. lafoniense*, Halle,[2] resembles *D. zalesskyi* in its low medullary rays and in some other features, but the structure of the pith is different, while the bordered pits are usually biseriate and apparently always contiguous. The species whose secondary wood most nearly resembles that of *D. zalesskyi* is *D. arberi*, Sew., a rather vaguely defined type widely distributed in the southern hemisphere. But as the name *D. arberi* has been applied to a variety of woods which probably include more than one species, it will be necessary to compare them individually.

(*a*) The species *D. arberi*, Sew.[3] (originally named *Araucarioxylon australe*, Arber),[4] was founded on Australian specimens showing only the secondary wood, a tissue which is unreliable for diagnostic purposes when we are dealing with woods of the *Dadoxylon* type. Assuming that these specimens all belong to the same species of plant (which is uncertain as the data are insufficient), *D. arberi* differs from the secondary wood of *D. zalesskyi* in its higher medullary rays, its more numerous field-pits, and in the tendency of the bordered pits to form groups.

(*b*) A South African wood, with pith and primary xylem preserved, was assigned by Walton to *D. arberi* in view of the resemblance in secondary structure. In identifying this and some other woods with *D. arberi* it was definitely intended to imply that no account is taken at present of other structures than those of the secondary wood.[5] The name *D. arberi* has thus come to be used in the sense of an aggregate species.

The South African plant agrees with *D. zalesskyi* in having no specialised perimedullary zone, but the pith is devoid of sclerotic cells, the medullary rays are higher, the pits in the field are somewhat more numerous and rounded, and the bordered pits on the tracheids tend to form groups.

(*c*) In another South African wood, described by Warren,[6] there are irregularly reticulate cells between the protoxylem and

[1] Holden, R., *op. cit.*, p. 320, (1916).
[2] Halle, T. G., *Bull. Geol. Inst. Univ. Upsala*, XI, p. 64, (1911).
[3] Seward, A. C., 'Fossil Plants', III, pp. 255-256, (under *D. nicoli*, Sew.), (1917); *ibid*, IV, pp. 177-178, (1919).
[4] Arber, E. A. N., 'The Glossopteris Flora', (London), p. 191, (1905).
[5] Walton, J., *Ann. S. Afr. Mus.*, XXII, p. 2, (1925).
[6] Warren, E., *Ann. S. Afr. Mus.*, II, Pt. 3, (1912).

the pith.[1] These alone would serve to distinguish the wood from *D. zalesskyi*, but there are also other points of difference.

(*d*) A Falkland wood originally named *D. bakeri*[2] was later identified by Walton[3] with *D. arberi*, the secondary structure being the same. *D. zalesskyi* differs from *D. bakeri* in its low medullary rays, in the absence of trabeculæ in the tracheids, in the fact that the bordered pits do not tend to lie in groups, and especially in the absence of any specialised perimedullary tissue.

(*e*) Another Falkland wood, imperfectly known but provisionally referred by Halle[4] to *D. angustum*, Felix, was also brought under *D. arberi* by Walton[5] the differences being regarded as trivial. Only the secondary wood is known. From *D. zalesskyi* this wood differs in its very narrow medullary rays, which also attain a greater height, in its thin-walled tracheids and in the fact that the rings of growth are not sharply marked.

(*f*) In 1926 Sahni and Singh assigned to *D. arberi* a wood from the Sugar Loaf Range in the Newcastle Coalfield, New South Wales.[6] The secondary wood differed from that of *D. arberi* in a few points, which were then considered unimportant; a closer resemblance was noticed with *Araucarioxylon daintreei*, Chapman. In view of the differences from *D. arberi* in the secondary wood, but chiefly owing to the very large pith, Kräusel[7] suggests that the specimen from the Sugar Loaf Range is distinct from both these species and should be given a new name. Seeing the justice of this criticism I have pleasure in naming the plant *Dadoxylon kräuseli*, sp. nov., the type-specimen being represented by Figs. 1-5 and 11-13 in Sahni and Singh's paper.[8]

From *D. kräuseli*, too, *D. zalesskyi* differs on account of its low medullary rays, its fewer and larger field-pits, the absence of rims of Sanio, and the sclerotic nests in the pith.

[1] Walton, J., in Seward, A. C., and Walton, J., *Quart Journ., Geol. Soc.*, LXXIX, p. 325, (1923).

[2] Walton, J., in Seward, A. C. and Walton, J., *op. cit.*, p. 327, (1923).

[3] Walton, J., *op. cit.*, p. 2, (1925).

[4] Halle, T. G., *op. cit.*, p. 68, (1911).

[5] Walton, J., *loc. cit.*

[6] Sahni, B., and Singh, T. C. N., *Journ. Ind. Bot. Soc.*, V, No. 3, pp. 103-112, (1926).

[7] Krausel, R., in Krausel und Range, 'Beitr. z. k. d. Karruformation Deutsch-Südwest-Africas, II, Fossil Pflanzenreste', p. 45, (1928).

[8] The type-specimen and the figured sections are preserved in the fossil collection of the Geological Survey of India, Calcutta, under registered type No. 15495.

COMPARISON WITH *MESOPITYS TCHIHATCHEFFI* (GOEPP.) ZALESSKYI.

An interesting point about *D. zalesskyi* is that it resembles *Mesopitys* (formerly *Dadoxylon*) *tchihatcheffi* in the possession of sclerotic nests in the pith and in the absence of secretory sacs.[1] Sclerotic nests are not found in any other known species from Gondwana Land; and the southern *Dadoxyla* as a rule have secretory elements in their pith. To this extent, therefore, *D. zalesskyi* differs from the southern types while resembling a northern form, an affinity which is perhaps not entirely unexpected. But the pith of *M. tchihatcheffi* is small, and it is probable that some of the primary bundles are mesarch.[2] The pitting is also different.

THE FOLIAGE OF THE INDIAN PALAEOZOIC *DADOXYLA*.

The Lower Gondwana rocks of India have yielded three species of *Dadoxylon* and three species of leaves which are presumably Cordaitalean.[3] But in the present state of knowledge any attempt to correlate the stems and leaves is futile, the more so as one of the leaf species (*N. Hislopi*) has been recorded from several other Gondwana countries[4] and may equally be claimed by other *Dadoxyla*. The number of *Dadoxylon* spp. at present recognized in the *Glossopteris* flora considerably exceeds the number of leaf species which can possibly be assigned to them. Either some new types of leaves remain to be discovered or one or more of the known forms, *e.g.*, *N. hislopi*, are aggregate species. One may say with some confidence that at least the Tonkin leaves figured by Zeiller[5] as *N. hislopi* do not belong to the same plants as the Indian leaves. The same may be true of some leaves from Mexico figured under that name by Wieland.[6]

[1] Zalessky, M. D., *Mém. Com. Géol. Russie*, (St. Pétersbourg), N. S., 68, (1911).

[2] Seward, A. C., 'Fossil Plants', III, p. 295, (1917); Scott, D. H., 'Studies in Fossil Botany', II, p. 283, (1923).

[3] *D. indicum*, *D. bengalensis* (Barakar age = Lower Permian), *D. zalesskyi* (Raniganj age = Upper Permian); *N. hislopi* (ranging from Talchir to Panchet age, that is from Upper Carboniferous to Trias), *N. stoliczkanus* (Karharbari = Upper Carboniferous) and *Euryphyllum whittianum* (Karharbari = Upper Carboniferous.)

[4] Argentina, Brazil, South Africa, Queensland, New South Wales and Tasmania.

[5] Zeiller, R., 'Flore fossile des Gîtes de Charbon du Tonkin', (Atlas), Pl. XL, figs. 2-4, (1902). In Zeiller's figures the veins converge again towards the apex, a feature never observed in the Indian leaves.

[6] Wieland, G. R., *Bol. Inst. Geol. Mexico*, No. 31, Pl. XXXVII, fig. 1, (1916), shows a leaf differing both in its form and in its more spreading veins from the true *N. hislopi*.

The identity once suspected between *N. hislopi* and the Siberian leaves *Cordaites æqualis*,[1] which Prof. Zalessky [2] has assigned to *Mesopitys tchihatcheffi*, also seems untenable; Mr. M. K. Eliashevitch [3] has found that the venation is different; moreover, the anatomy of the Indian leaves is still unknown, nor has *M. tchihatcheffi* yet been found in Gondwanaland.

The Asansol fossil is named *D. zalesskyi* as a tribute to the distinguished work of Prof. M. D. Zalessky on the Palæozoic floras of Siberia. It perhaps affords some little support to the view that the Palæozoic flora of the Angara series was more akin to that of India than to that of any other part of Gondwanaland.

SUMMARY.

The new species *Dadoxylon zalesskyi* is based upon a silicified stem found near Asansol in the Raniganj coalfield, Bengal, in strata assigned to the top of the Raniganj series of the Lower Gondwanas; this series is regarded as homotaxial with the Upper Permian of Europe. There is a large non-discoid parenchymatous pith devoid of secretory elements but containing scattered nests of sclerotic cells. The primary bundles are endarch and abut directly upon the pith; the centrifugal xylem passes insensibly into the secondary wood. In the latter sharply marked growth-rings are seen. On the radial walls of the tracheids the bordered pits lie in one to four rows; they are mostly of the rounded distant type (opposite or alternate) but the contiguous hexagonal type is also represented; the medullary rays are low; pits in the field, one to three or four, large simple, circular or oval. Comparisons with several species recorded from India and other Gondwana countries as well as with the Siberian form *Mesopitys tchihatcheffi*, Gœpp. sp., reveal a general affinity with the *Dadoxyla* characteristic of the *Glossopteris* flora, but the absence of secretory elements and the presence of sclerotic nests in the pith are interesting points of resemblance with the Siberian species.

[1] Kosmovsky, C., *Bull. Soc. Imp. des Naturalistes de Moscou*, No. 1, p. 174, (1891); Zalessky, M. D., *Mém. Com. Géol. Russie*, N. S., 86, (St. Pétersbourg), (1912).

[2] Zalessky, M. D., *Bull. Soc. Géol. France*, 4th ser., XXVII, fasc. 8-9, p. 380, (1917), and *Mém. Com. Géol. Russie*, N. S., 174, especially Pls. LV-LIX, (1918).

[3] I am indebted to Mr. Eliashevitch for a letter in which he shows that in *C. aequalis* the veins are more spreading and begin to reach the margin at the very base of the leaf, while in *N. hislopi* they are more nearly parallel and only reach the margin in the broad part of the leaf.

So far as it is known at present, *D. zalesskyi* is confined to a particular horizon (the Kumarpur sandstone stage) in the Raniganj series, which is characterised by an abundance of fossil wood, a great part of which seems to have belonged to this species. To judge by the size of several silicified trees recently found near Asansol the plants may easily have attained a height of 35 to 40 metres; and they probably grew in great abundance. The major branches were few and apparently came off at a narrow angle, but there were numerous small branches, of which the scars have been found scattered over the main trunk.

Neither bark nor roots are preserved. Nothing is known of the leaves; in the Raniganj series Cordaitean leaves of the *Noeggerathiopsis hislopi* type are abundant; but there is no evidence of a connexion, and there are several species of *Dadoxylon* to claim this foliage, which is also found in other parts of Gondwanaland.

A specimen of *Dadoxylon* from New South Wales, previously assigned to the widely distributed but vaguely defined species *D. arberi*, Seward, is now placed in a new species, *D. kräuseli*.

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EXPLANATION OF PLATES.

PLATE 23, FIG. 1.—*Dadoxylon zalesskyi*, sp. nov. Type-specimen. (× *ca.* 2/5).

FIG. 2. Type-specimen. Cross-section of a branch. (× 1).

FIG. 3. Part of the same section. (× *ca.* 8).

FIG. 4.—Type specimen. Cross section of main axis at C (Fig. 1 on p. 416), to show origin of two leaf-traces. (× *ca.* 45).

FIG. 5.—Type-specimen. Longitudinal section of branch. (× 10). (*br.*, branch ; *l.-t.*, leaf-trace ; *p.*, pith ; *px.*, protoxylem ; x^1, primary xylem ; x^2, secondary xylem).

PLATE 24, FIG. 1. *Dadoxylon zalesskyi*, sp. nov. Type-specimen. Cross-section of branch to show structure of pith. (× *ca.* 51).

FIG. 2.—Part of the above section, to show a sclerotic nest. (× *ca.* 142).

FIG. 3.—Type-specimen.—Longitudinal section of branch, to show structure of pith. (× *ca.* 70).

FIG. 4.—Type-specimen.—Bordered pits in spring wood. (× 450).

FIG. 5.—Type-specimen.—Radial section of branch to show a medullary ray with pits in the field. (× *ca.* 360).

FIG. 6.—Radial section from small tree found south of the Kumarpur cutting to show distribution of medullary rays. (× 17·5). (*scl.*, sclerotic cells ; *l. scl.*, lumen of sclerotic cells ; *cav.*, cavity in pith ; *par.*, parenchyma ; *aut.*, autumn wood ; *spr.*, spring wood).

A FOSSIL PENTALOCULAR FRUIT FROM PONDICHERRY, SOUTH INDIA. BY B. SAHNI, *Professor of Botany, Lucknow.* (With Plate 25.)

INTRODUCTION.

The specimen shown in the natural size photograph forming Plate 25, figure 1, was kindly lent to me for description several years ago by Dr. F. A. Bather, F. R. S., then Keeper of Geology at the British Museum (Natural History). There is no record of the age of the fossil, but the nature of the matrix,[1] coupled with the fact that the locality is stated as Pondicherry, indicates that the fossil either belongs to the Cuddalore series (Tertiary) or to the Upper Cretaceous.[2] Both these formations are represented near Pondicherry. Mr. D. N. Wadia informs me that about ten miles W. N. W. of the town, there occurs an outcrop of the so-called Pondicherry Cretaceous[3] surrounded to the east as well as to the west by bands of Cuddalore sandstones.

A few fragments of molluscan shells are embedded in the same matrix as the fruit, but it has not been possible to identify them. The nature of the matrix itself, however, points to a Cretaceous rather than a Tertiary horizon. The following description is based upon petrological reports kindly supplied by the Geological Survey of India and by Mr. W. Campbell Smith of the British Museum:

> The rock is a very fine-grained calcareous grit, containing a high proportion of angular sand-grains, orthoclase and plagioclase felspars, hornblende, garnet, spinel, sphene and opaque black ores, cemented together by an abundant calcareous matrix. The general freshness of the felspars and the angular nature of many of the fragments suggests that the rock has been formed of the decomposition products of a granitic rock or gneiss at no great distance from the shore.

Mr. Campbell Smith also very kindly undertook to compare this rock with a specimen from Rautankuppam (west of Pondicherry, near the French border), which almost certainly belongs to the

[1] I am very grateful to the authorities of the British Museum for the loan of the fossil, and to the Director of the Geological Survey of India for having the matrix petrologically examined for me. The rock is a fine-grained calcareous grit in which a few unidentifiable molluscan shells are embedded.

[2] Wadia, pp. 205, 209, (1920).

[3] Warth, (1895); Kossmat, (1897).

Valudayur or *Anisoceras* beds of Kossmat[1]; the matrix bore such a striking external resemblance to that of the first specimen that a detailed comparison seemed promising. The result of this comparison, summarized below, speaks for itself:

Both rocks are very fine-grained calcareous grits. Both contain a high proportion of angular sand grains, insoluble in HCl. Samples separated by dissolving the limestones in dilute HCl yield similar assemblages with minor differences. The minerals observed in both rocks are as enumerated in the description given above. The rock from Rautankuppam has smaller grains; felspar is relatively to quartz much more abundant, garnet and opaque ores less so; also flakes of brown biotite are present. '*I should say that the two rocks are not from the same locality, but they might well be from the same formation.*' W. C. S.

I am greatly indebted to the authorities of the Geological Survey of India, Prof. Rama Rau, Mr. W. N. Edwards and especially to Mr. Campbell Smith; thanks to the trouble taken by these gentlemen, it has been possible to determine the age of the fossil as Upper Cretaceous with some degree of probability. It is also a pleasant duty to express my gratitude to the authorities of the British Museum for permission to investigate the material; to Professor A. C. Seward, F.R.S., for his valued criticism, and to Professors P. Parija (Cuttack) and S. P. Agharkar (Calcutta) for helpful suggestions in comparing the fossil with modern angiosperm fruits.

DESCRIPTION.

From the photograph (Pl. 25, fig. 1), which represents a slightly oblique dome-shaped cross-section (compare fig. 2), the pentalocular nature of the fruit is quite evident; one of the loculi is abortive. The fruit is here about 2·7 cm. in diameter. The small round cavity at * is no doubt accidental as sections have shown.

The fossil was cut along the planes marked in fig. 2, Plate 25. As indicated in this diagram, the fruit rounds off at the lower end. The length of the fruit is unknown, but the indications are that it was not much longer than broad. At the levels B, C and D, the remains of five radiating septa are clearly seen; at E they have

[1] This specimen was collected by Mr. H. Sitarama Rau, B.Sc., of Lucknow University, during a recent excursion to southern India. I am informed by Prof. L. Rama Rau of the Geology Department, Central College, Bangalore, to whom also the specimen was submitted for inspection, that this type of rock is fairly common near Rautankuppam and Tutipet; *see* Warth, p. 17. (1895) and Kossmat, p. 56, (1897) where these localities are mentioned. Considering the locality where it was found, and the fact that the rock is crowded with *Turritella* and other marine shells, its reference to the Pondicherry Cretaceous is scarcely open to any doubt.

become indistinct. In each loculus, except the abortive one, there is a single large slightly compressed seed, placed with its long axis vertical and with the major transverse diameter radial. The seeds were evidently of very considerable length, as two of them have been followed down to the level D (Pl. 25, fig. 2).

The structure of the fruit wall and of the septa is not clearly preserved. The whole appearance, however, suggests that the fruit was not woody. The seeds are not lying freely in the loculi but are embedded in a matrix which appears to have been comparatively soft and may even have been succulent, as in a sapota fruit (sapodilla plum = *Achras sapota*).[1] In the central axis a small ring of light-coloured dots (Pl. 25, fig. 3) no doubt represents the vascular cylinder. The mode of attachment of the ovules is not visible.

In one of the seeds (No. 2 in figs. 1 and 3), the form and structure of the integument is fairly well preserved. Owing to the obliquity of the section the seed-cavity here appears wider along the minor diameter than it actually was. Figs. 1 and 5 show that at the level A the integument converged towards the outer side into a beak-like process; but as the same feature is seen at a level 1 mm. lower down (fig. 3), this process is more appropriately compared to the keel of a boat. In the region of this keel, which must have extended for at least 4 mm. along the outer margin of the seed, the integument is markedly thickened in a characteristic manner (figs. 1 and 5), somewhat recalling the caruncle of some Euphorbiaceæ. In figure 5, the narrow prolongation of the seed-cavity almost reaches the surface, suggesting the proximity of an outwardly directed micropyle, which again reminds one of the Euphorbiaceæ and a few other families.

Over the greater part of the seed, the integument is about 0·75 to 1 mm. thick, and no doubt formed a tough shell, with a smooth exterior. It is clearly differentiated into two layers. The thick outer layer has a prismatic structure, the columnar cells being placed vertically to the surface; the preservation is too poor to show whether this layer contained any products of secretion. The inner layer, seen as a thin white line in figure 3, does not show any structure. The contents of the seed cavity are not preserved except in seed No. 2, where they are too badly shrunken to bear description.

DISCUSSION OF AFFINITIES.

There would seem to be little doubt that the fruit belongs to a dicotyledonous plant. But without fuller data, it is not possible to determine the exact affinities, although several well-defined features are preserved. The number of existing dicotyledonous families in which there is a syncarpous multilocular fruit having a single large seed in each loculus, with a thick two layered integument and with the micropyles facing away from the axis, is not large. If the fossil belongs to a living family, it may not be difficult for a systematist to place it in its exact position. But there are, in addition, many other families in which the structure of the fruit varies through a wide range; this fact makes the task of comparison difficult. Nor can we exclude the possibility that the fossil belongs to an extinct group. So far as I have been able to consult the literature, I have not come across any particular genus, either living or fossil, with which our fossil agrees sufficiently well to be identified. On the whole an affinity with the sympetalous order Ebenales of Engler (which includes the families Sapotaceæ and Ebenaceæ among others) seems more probable than any other.

In its general characters the fossil shows a fairly close resemblance to the genus *Achras* of Linneus (*Sapota*, Plumier)[1]. The Sapotaceæ are fairly well represented in the Cretaceous and Tertiary of both the northern and southern hemispheres, by leaf impressions many of which are probably correctly assigned to this family.[2] Some fossil woods have also been assigned to the genus *Sapotoxylon felix*.[3] The monotypic genus *Achras*, now confined to the West Indies was, according to Berry,[4] represented by three species (based on leaf-impressions) in the Miocene of Europe. Menzel states,[5] however, that the fossil fruits which have been referred to the Sapotaceæ show nothing to prove that they belong to this family.

In our fossil, the points of resemblance with the sapota lie in the multilocular nature of the fruit; in the presence of a single

[1] For a detailed illustrated description of *Achras sapota*, see Engler in Engler and Prantl, pp. 137-138, figs. 73 A-D, (1897).

[2] Menzel in Potonié-Gothan, p. 399, (1921).

[3] *See* Edwards, pp. 74, 78, (1931).

[4] Berry, p. 238, ff., (1914).

[5] *Loc. cit.*

seed in each loculus;[1] and in the size and form of the seed, which in both cases is placed vertically, with the major diameter radial. If the thickened margin of the integument, to which attention has been drawn, marks the position of the hilum, we have a further point of similarity although in the sapota the hilum is not marked by such a pronounced thickening of the testa. The seeds of the fossil, like those of the sapota, evidently had a hard, woody testa, differentiated into two layers, but the structure of the outer layer was different. A very important point of difference, however, lies in the position of the micropyle, which faces inwards (towards the axis of the fruit) in the modern genus, while in the fossil, as we have seen, it was probably directed outwards. Were it not for this difference, there would probably have been no serious objection to our assigning the fossil to the Sapotaceæ.

Another modern genus with which perhaps an even closer comparison may be made is *Diospyros*, a member of the allied family Ebenaceæ. The fruit of *D. kaki* (persimmon) resembles our fossil and also that of *Ichnas* in several features: the ovary is multilocular, with a single seed in each loculus; the seed is large, compressed, with a tough smooth shell, and is placed vertically in the loculus with the major diameter radial. The raphe, however, is dorsal and the micropyle upwardly directed. There can be no question of referring the fossil to this genus, but the resemblance is undoubted.

The fossil record of the Ebenaceæ[2] is much more substantial and satisfactory than that of the Sapotaceæ. Numerous leaf-impressions, parts of flowers (especially the calyx), fruits and petrified woods[3] have been referred to this family, many of them apparently on good evidence, from the Cretaceous and Tertiary of North America, Greenland, Europe, Africa, Asia and Australia. Many of these fossils have been assigned to *Diospyros*, but other genera have also been identified. From the early Tertiary of the Panama Canal Zone Berry has described a petrified multilocular fruit which he has named *Diospyros macdonaldi*[4]; the transverse section (comparable with our figs. 1 and 3 in Pl. 25) shows several loculi of different

[1] Assuming, as I think we may, that the fossil fruit was not much longer than it was broad.

[2] *See* Menzel in Potonié-Gothan, pp. 399-400, (1921), and especially Berry, pp. 255-269, (1923).

[3] Edwards, pp. 31, 38-39, (1931).

[4] Berry, p. 261, fig. 48 (8, 9), (1923).

sizes radiating from a central vascular axis. The reference to the living genus may ultimately prove to be correct, but at present no further details are available in support of it. This new world species, however, offers the nearest analogy among fossil plants that I have yet been able to trace with the Pondicherry fruit. Were it not for the structure of the integument, and especially the position of the micropyle, our fossil might well have been assigned to the same genus. In any case the resemblance, so far as the other features are concerned, is very close, and may be due to real affinity.

It now remains to refer briefly to a few other fruits, living and fossil, with which our specimen may be compared, although none of these comparisons are so helpful as those just indicated.

The outwardly directed micropyles of our fossil recall to some extent those of the Euphorbiaceæ. The resemblance is enhanced by the marked thickening of the shelly integument, which may be compared with the caruncle characteristic of many members of that family.

The Sterculiaceæ are another family in which the fruit may be large and multilocular, while the ovules, too, may be large and have their micropyles turned outwards. But I do not know of any single genus which combines the characters of the fossil. Under the name *Sterculiocarpus coccineus*, Berry,[1] has figured a large, apparently woody, pentalocular fruit from the Eocene of America; but as no sections were made, only the external features are described. Obviously, therefore, the reference to the Sterculiaceæ must be regarded as provisional.

The genus *Sezannella* of Munier-Chalmas, from the Eocene travertine deposits of France, was referred on very strong grounds to the Sterculiaceæ[2]. The ovary in this genus was syncarpous and 5-locular as in our fossil, but the fruit was capsular and had two series of horizontally placed ovules in each loculus.

A few Malvaceæ and Dilleniaceæ also possess fruits showing some of the characters of our fossil, but the resemblance is not sufficiently striking to deserve serious notice. Other families which may possibly afford a clue to the affinities of our fossil are the Geraniaceæ, Rutaceæ and Zygophyllaceæ.

In some respects our fossil shows a close resemblance with *Saccoglottis cipaconensis*, Berry,[3] a pentalocular fruit from the Tertiary

[1] Berry, p. 288; Pl. 74, figs. 1-3, (1916).
[2] Viguier, p. 6, (1908).
[3] Berry, pp. 124-126; Pl. 20, figs. 8-16, (1927).

of Colombia and Peru; another species, *S. tertiaria*, Berry,[1] is known from Bolivia. The genus is modern, a member of the small and obscure South American family Humiriaceæ. There is an undoubted resemblance with our fossil in the pentalocular character of the fruit and in the presence of a single large seed placed vertically in each loculus. But there can be no question of generic identity or even a close affinity. *Saccoglottis* has a stony fruit, with the surface pitted with secretory cavities. In *S. gabonensis*, these cavities exist also in the stout woody septa which, moreover, thicken outwards like wedges. No details of the integumental structure are available, but in *S. tertiaria* the seed is shown with large and conspicuous resin pits.

The few selected comparison cited above—and the number could easily be multiplied--illustrate the wide range of modern angiosperms through which a search must be made for possible indications as to the systematic position of our fossil. The comparisons with the sapota and with *Diospyros* are the nearest I have been able to trace.

For the reasons given above the fossil is referred to a new genus, named after the locality, the resemblance with the order Ebenales being indicated by the specific name.

Pondicherrioidea, gen. nov.

Syncarpous multilocular fruits having a single large compressed seed placed vertically in each fertile loculus, with its major transverse diameter radial; micropyle outwardly directed (position of raphe unknown); integument hard, smooth, two-layered, thickened near the micropyle.

The nearest affinity so far recognisable is with the sympetalous order Ebenales of Engler, and especially with the genera *Achras* (Sapotaceæ) and *Diospyros* (Ebenaceæ). The only known species is—

Pondicherria ebenaleoidea, sp. nov.

A relatively soft fruit above 2·7 cm. in diameter; loculi about 5, one or more of which may be abortive; integument markedly thickened near the micropyle, forming a broad keel along the outer edge of the seed; outer layer of integument consisting of palisade-like cells.

Locality.—Pondicherry, South India.

Geological age.—Unknown, probably Upper Cretaceous (*vide supra*).

[1] Berry, pp. 129-130, figs. 1a-c, p. 128, (1922).

Type-specimen Geology Department, British Museum (Nat. Hist.) V. 21756.

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EXPLANATION OF PLATE.

PLATE 25, FIG. 1.—*Pondicherria ebenaleoidea*, gen. et. sp. nov. Photograph of a natural (weathered) cross section of the fruit. (Nat. size.)

FIG. 2.– Diagram of a side view of the specimen, to show how the fossil was sectioned. The form of the fruit is shown in the dotted area, as if the embedding matrix of rock were transparent. Further explanation in the text. (Nat. size.)

FIG. 3.—Photograph of a section at level B (fig. 2). (× 2½).

FIG. 4.—Enlarged outline (diagrammatic) of seed No. 2 at level B. (× *ca.* 5½).

FIG. 5.—Enlarged outline (diagrammatic) of the same seed from level A. (× *ca.* 5½).

THE KALAVA (CALWA) 'WALL' IN THE KURNOOL DISTRICT OF THE MADRAS PRESIDENCY: AN EXAMPLE OF MONOCLINAL FOLDING, ACCOMPANIED BY FAULTING, PROBABLY ALONG AN OLD LINE OF WEAKNESS. BY A. L. COULSON, M. SC. (MELB.), D.I.C., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 26.)

Introduction.

During his investigations of the barytes and asbestos resources of the Cuddapah, Anantapur and Kurnool districts of the Madras Presidency, the author had occasion to visit that structure in the vicinity of Kalava (15° 37′: 78° 12′ in the Kurnool taluk of the Kurnool district, called by R. B. Foote a quartzite 'wall'.[1]

The structure is an example of monoclinal folding, accompanied by faulting, probably along an old line of weakness. As its detailed description would be out of place in the author's economic report on the barytes and asbestos deposits, it has been decided to publish this account separately. This procedure has the additional advantage of drawing attention to a structure which merits a wider publicity than it at present enjoys. The area is fairly easy of access and offers good possibilities in instructive training for parties of students from various universities.

Position of Kalava

Kalava is a moderate-sized village, unfortunately rather malarious, which enjoys the advantages of a post office and possesses a good camping ground. There is, also, a small, though good, two-roomed rest house, 1¾ miles W. S. W. of the village and situated actually on the 'wall' between miles 205 and 206 on the Chittoor-Kurnool road.[2] This Kalava rest house is 20 miles S. S. E. from Kurnool and 17 miles north-west from Paniem along a good road (Chittoor-Kurnool), and is also 13 miles north of Betamcherla along a fair road. Kurnool is a station at mile 151 from Secunderabad on H. E. H. the Nizam's Guaranteed State Railway from Secunderabad to Dronachellum (Dhone); Panyam and Betamcherla are stations on the Madras and Southern Mahratta Railway at miles 82 and 66 from Guntakal

[1] W. King, *Mem. Geol. Surv. Ind.*, VIII, pt. 1, pp. 65-66, (1872).

[2] Between miles 20 and 21 from Kurnool, as shown on the 1921-22 one-inch map sheet 57¾. The mile-posts have since been altered as indicated in the text.

on the Guntakal-Bezwada line. Motor buses run from Kurnool to Paniem and also to Betamcherla.

Extent of the Kalava wall.

The Kalava wall of Paniam quartzites extends from Kalava rest house to Chennakkapalle. This paper, however, includes a description of the westward continuation of the scarp of Paniam quartzites from the rest house to east of Ramallakota. As will be seen, this scarp is partly an erosion scarp, but the formation of its western (Ramallakota) end is very intimately connected with the post-Kurnool faulting,—King's Gunnygull fault—which occurred at the time of the formation of the Kalava wall.

Classification of Cuddapahs and Kurnools.

The following table shows the constituent members of the Cuddapah system and Kurnool series as classified by King in his classic memoir, 'On the Kadapah and Karnul Formations in the Madras Presidency'.[1] The spelling of the names has been modernised in accordance with Sir Thomas Holland's 'Indian Geological Terminology'.[2] The names, however, do not all agree with those in modern maps; but in order to avoid possible confusion, no further changes have been made.[3]

Lower Vindhyan system (Purana)	Kurnool series	Kundair stage	Nandyal shales
			Koilkuntla limestones
		Paniam stage	Pinnacled Quartzites
			Plateau Quartzites
		Jammalamadugu stage.	Auk (Owk) shales
			Narji limestones
		Banganapalli stage	Sandstones
	Large unconformity		
Cuddapah system (Purana)	Kistna series .		Srisailam quartzites
			Kolamnala slates
			Irlakonda quartzites
	Unconformity		
	Nallamalai series		Cumbum slates
			Bairenkonda quartzites
	Unconformity		
	Cheyair series.		Pullampet slates=Tadpatri shales
			Nagari quartzites=Pulivendla quartzites
	Unconformity[4]		
	Papaghni series		Vaimpalli slates and limestone
			Gulcheru quartzites
	Great Unconformity		
Archaean . .	Crystalline rocks		

[1] *Mem. Geol. Surv. Ind.*, VIII, Pt. 1, pp. 1 313, (1872).
[2] *Op. cit.*, LI, pt. 1, pp. 1-184, (1926).
[3] To give but one example:—The railway station is Panyam; the village on one-inch sheet 57 I/6 is Paniem; and the geological formation is the Paniam quartzites (previously Paneum quartzites).
[4] The present author considers that this unconformity is practically non-existent.

Intrusive[1] sills of basic igneous rocks are associated with the Vaimpalli slates and limestones and with both stages of the Cheyair series. The exact age of these rocks is a problem which has a very distinct bearing on the barytes and asbestos deposits and will not be discussed here.

Intrusive traps.

Foote's notes, which were quoted in full by King,[2] are reproduced here for easy reference. The modernised spelling of certain names has been inserted in parenthesis to facilitate easy reference to modern topographical maps. The spelling given by King is that of the quarter-inch Atlas of India sheets used by Foote and himself.

Notes by Foote.

'The most interesting and remarkable feature in the position of the quartzites (Paniam) is the singularly long and narrow wall joining the north end of the Oon-dootla (Undutla; sheet 57 I/6) plateau with that of Chintalpilly (Chintalapalle; sheet 57 I/2). This narrow wall of rock owes its existence to the action of the two opposite forces of upheaval and denudation. By the first a large area was elevated, forming the whole of what has been described as the Oondootla and Chintalpilly plateau and the intervening space, the northern and central parts of the elevated region, was removed by the denuding force, thus disclosing a considerable tract of the underlying rocks which chiefly belong to the older or lower series of the newer metamorphic rocks, the KADAPAH ROCKS. This remarkable wall of quartzite corresponds with a line of fault, but there has been apparently little or no dislocation of the strata on either side of the fracture. The action of the denuding forces, however, has been unequal, and the various outliers of pinnacled quartzite and the underlying strata, limestones and diamond-quartzites, render the geology of the area of denudation south of the wall most interesting and rather complicated. Of the pinnacled quartzite only two outliers remain, one about two and a half miles east of the large village of Calwa (Kalava); it is of small extent only, but important and conspicuous, because perched on the top of a short flat-topped ridge rising nearly 300 feet above the valley. The top is capped with the quartzites, and distinguished by several fine specimens of pinnacle "tors". This capping rests upon a great thickness of "Owk shales" and the east end of the ridge offers a capital exposure of these underlying rocks. This small outlier at once explains the formation of the quartzite wall. The wall, for that is the best name descriptive of the long narrow line of outcrop of the quartzite, measures about 13 miles from Chennagapilly (Chennakkapalle; sheet 57 1/6), westward to its junction with the Chintalpilly plateau. Throughout this whole distance it retains its characters of an independent ridge wall, except for about half a mile along the base of the Goomanconda (Gattimanikonda), where it leans against the hill.

[1] These sills have usually been referred to as 'contemporaneous lava flows' in the Cuddapahs. King himself, however, noted their intrusive relationships in several exposures (*op. cit.*, pp. 198, 200 and 203). All the dolerites and basalts seen by Dr. C. S. Fox [*Rec. Geol. Surv. Ind.*, LXV, p. 34, (1932)] and the author are intrusive in the Vaimpallis and Cheyairs in which they occur.

[2] *Op. cit.*, pp. 65-66.

'The northward dip of this great basset edge or outcrop is generally very high indeed, varying from 60° to 80°. Except in one place a little south-west of Calwa the top of the ridge is extremely narrow, often not more than 20 to 30 feet. But near Calwa the bed shows a double dip, as shown below in section, owing to less complete denudation for a distance of three or four hundred yards, to the south of Bapunpilly (Brahmanapalle; sheet 57 I/2), where the wall-like character of the quartzite outcrop is extremely well developed; this bed rises in cliffs, but little short of a hundred feet high above the valley of the Khoond-air. At foot of the quartzite wall, the Koilkoontla limestone appears in very many places dipping north at an equally high angle; but as it is followed in to the plain the dip rapidly decreases, and before it crosses the bed of the Khoond-air, the beds approach very nearly to horizontality. The quartzite is throughout the length of the outcrop very white in color, and differs only from the less disturbed portions of the formation in being less distinctly laminar,- a change of character which may have been brought about by the enormous pressure and consequent heat during the process of dislocation at that very part of the originally undisturbed bed. The mass of the rock in the wall is much more broken up by irregular fissures than where inclined at a low angle.'

Foote's section, which is Figure 8 in King's memoir, is omitted as it is incorrect. The Paniams are shown as being unconformable upon (and unfaulted against) the older Cuddapahs. King, following Foote, considered that his 'Gunnygull' fault, which is along the continuation of the Kalava wall, to be post-Kurnool in age.[1]

King's notes.

'Of faulting to any decided extent which has affected the KARNUL rocks there are only two examples. The one has taken place in a nearly east-west direction along the Gunnygull (Gani Ghattu; sheet 57 I/2) ridge, east-south-east of Ramulkota (Ramallakota), and the northern flank of the Oondootla (Undutla) plateau. It is a fault the throw of which commenced imperceptibly at the eastern end of the line near Gunny (Gani; sheet 57 I/6), until at its western end, it amounted to more than 300 feet. Along the flank of the Oondootla plateau the limestones and quartzites are bent down with a sharp dip, as is described already in Mr. Foote's account of the "wall" of Calwa (Kalava); which dip, as one proceeds westward, is found to become so sharp as to indicate a decided fracture in the strata; and this becomes more and more distinct the nearer the Gunnygull ridge is approached. At first, after the sharp roll-down of the beds is traced out past Calwa, it is found that the Nerjee (Narji) limestones are brought sharp up against a scarp of quartzites (pinnacled beds) of the *Paneum* group without having any room to slip under them, as they ought to do; and then as the line is traced still further westward the *Banaganpilly* (Banganapalli) quartzites begin to crop out from under the limestones at very nearly the same level as the pinnacled beds (which still, however, keep their own level along the north side of the fault) until they run well over the upland country towards and almost on to the Gunnygull ridge, when the pinnacled beds show down below in the flat Kortycoonta

[1] *Op. cit.*, pp. 122-123.

(Kortikunta) plateau north of Gunnygull. Also, the *Banaganpilly* group is again found on this north side of the fault 300 feet below at Ramulkota, where it has cropped out from under the limestones, Owk shales, and pinnacled quartzites of the Kortycoonta plateau. The downthrow then was on the north side, and this is evidenced by the up-turned beds against the northern flanks of the Gunnygull hill. This line of fault runs right out in a westerly direction into the granitoid gneiss country beyond this western edge of our rocks as is shown by the ridge of fault-rock striking through Yeldoorly (Velduiti; sheet 57 E/14) hill.'

Ramallakota-Gani fault.

The present author holds that King has failed to recognize the presence of another and earlier fault, pre-Kurnool in age, the Ramallakota-Gani fault, which is chiefly responsible for the Gani Ghattu (Gunnygull of King) dislocation (*see* p. 441). This pre-Kurnool fault probably runs more or less along the line of the Kalava wall from west of Ramallakota (15° 34′: 78° 0′) to south of Gani (15° 40′: 78° 19′); but of this it is not possible to be absolutely certain on account of the masking of the older Cuddapah rocks by the younger Kurnools. At the Gani end of the Kalava wall, there is certainly an old fault, definitely pre-Kurnool, by means of which the Vaimpalli limestones here have been thrown into juxtaposition against the much younger Tadpatri shales. This fault is more or less parallel to the trend of the quartzite wall, and is but a short distance south of it. The Tadpatris have rolling dips, north and south, whereas the Vaimpallis and the overlying Pulivendlas have generally a north-easterly dip.

Gattimanikonda fault.

The Ramallakota-Gani fault is the same age as the Gattimanikonda fault [1] a few miles further south, which, strangely enough, was not recognised either by King or by Foote; yet the Pulivendla quartzites north of the fault have been moved some three miles to the west and Tadpatri shales crop out against Vaimpalli limestones and Pulivendla quartzites. The structure of the Gattimanikonda fault is masked to a large extent by the covering layer of Banaganpalli quartzites; but the signs of faulting between Gattimanikonda and Venkata-

[1] The village and hill of Gattimanikonda are universally known locally as Gooramanaconda, their old name. It is a pity that the name has been changed in the modern maps.

There are numerous other major faults in the Kurnool, Anantapur and Cuddapah districts, affecting the Papaghnis and Cheyairs, which are of the same age as the Ramallakota-Gani and Gattimanikonda faults. These are described in the author's economic reports [*Mem. Geol. Surv. Ind.*, LXIV, Pt. 1, (*in the press*) and Pt. 2 (*under compilation*)].

puram are extremely clear. The dip of the Pulivendlas and Tadpatris to the north of the Gattimanikonda fault is to the E. N. E., whereas that of the Vaimpallis and Pulivendlas to the south of the fault is practically due east. Even assuming a uniform easterly dip of as low as 5° (the fault trends E.–W.), the throw of this Gattimanikonda fault to the north is little less than 1,400 feet.

Ramallakota - Gani fault is a hinged fault.

The Vaimpalli limestones at Gani, which lie to the south of the Ramallakota-Gani fault, are situated over 12 miles east of the similar rocks north of the Gattimanikonda fault (*i.e.*, over nine miles east of the similar rocks south of the Gattimanikonda fault). On the other hand, the Vaimpalli limestones north of the Ramallakota-Gani fault, if the nearest outcrop were projected along its strike to the fault, would crop out some five miles west of the similar Vaimpalli limestones north of the Gattimanikonda fault. Therefore it would appear that the pre-Kurnool Ramallakotta-Gani fault is in the nature of a hinged fault, the eastern (Gani) part of which has a downthrow to the south, and the western (Ramallakota) part of which has a downthrow to the north. The downthrow must, in each case, be of the nature of several thousands of feet and so, spectacularly, the Kalava wall fades into insignificance beside its much older compeer, the Ramallakota-Gani fault. King has given a possible downthrow of 300 feet for his Gunnygull fault which accompanied the formation of the Kalava wall; this throw is small compared with that of the ancient Ramallakota-Gani fault at its Ramallakota end. Moreover, it is unlikely that the small, post-Kurnool, Gunnygull fault would be responsible for the fault-rock mentioned by King. It is considered by the present auther that this fault-rock, and the hæmatite associated with it,[1] are pre-Kurnool in age. In other words, King's Gunnygull fault is really a post-Kurnool movement at the Ramallakota continuation of the Kalava wall, more or less along the line of the old pre-Kurnool Ramallakota-Gani fault.

[1] *Op cit.*, p. 277. It is interesting to note that recently there has been considerable activity in connection with this deposit of iron-ore. A licensee who worked the plot in 1925 left between 2,000 and 3,000 tons on the surface of his plot which is in Veldurti (57 E/14; 15° 33′: 77° 56′) lands. The stock became the property of Government. An average sample analysed in the laboratory of the Geological Survey of India gave 59·12 per cent. of metallic iron and 16·32 per cent. of silica. The same plot has since been applied for, and granted to, another applicant.

A great length of time must have elapsed between the occurrence of the Gattimanikonda and the Ramallakota-Gani faults and the laying down of the Banganapalli sandstones and diamondiferous grits.[1] This is perhaps most clearly seen in the field on the edge of the plateau north-west of Gattimanikonda village where the Banganapallis overlie the Gattimanikonda fault. The Gulcherus, Vaimpallis, Pulivendlas, Tadpatris, etc., were eroded to a peneplain before the deposition on them of the Banganapallis. The diamonds in the Banganapalli grits, for which intensive search has been made in this neighbourhood and further to the west on sheet 57 I/2 in the vicinity of the villages of Virayapalle, Repalle and Balaparam, were, it is suggested, derived by weathering from the intrusive trap sills in the Vaimpallis and Tadpatris.[2]

Erosion period and laying-down of the Kurnool series.

The Banganapallis were succeeded perfectly conformably by the Jammalamadugus, Paniams and Kundairs. After the deposition of the Nandyal shales, the higher members of the Kundairs, there was a recrudescence of earth movement on a large scale, and a general uplift of the country under the Nandyal sea took place. The movement, however, was far from even and certain areas were uplifted far more than others. Thus south of Kalava, at Sukkala Moru, the Banganapallis crop out at an elevation above sea-level of 1,753 feet; whereas at Kalava, the Kundairs, the highest members of the Kurnool series, crop out at 1,094 feet, both places being more or less comparable from the point of view of strike. Between them lies the Kalava wall, formed at this post-Kurnool (post-Kundair) period, and undoubtedly accompanied by faulting.

Earth movement: formation of the Kalava wall.

As Foote and King both recognized, the extent of the faulting varies largely. In places there is practically no fault and the wall is merely an erosion scarp of the Paniam quartzites. The throw of 300 feet at the Ramallakota continuation of the wall has already been mentioned in the discussion of King's Gunnygull fault. Towards Lingalapalle (15° 34′ 30″ : 78° 5′), faulting has

The continuation of the Kalava wall from Ramallakota to the Kalava rest house.

[1] It is unlikely that representatives of the Nallamalais and Kistnas extended as far west as the area under description. The faulting, however, is certainly pre-Kistna and post-Cheyair, *i.e.*, roughly Nallamalai to immediately post-Nallamalai in age.

[2] This point has been discussed in the author's report on the barytes and asbestos occurrences [*see Mem. Geol. Surv. Ind.*, LXIV, Pt. 1, pp. 115-116 (*in the press*)].

undoubtedly taken place as east of this village, the Paniam quartzite are in juxtaposition with the Banganapallis. Following the scarp south of Chintalapalle (15° 35′ : 78° 7′ 30″) and Palakolanu towards Kalava rest house, Jammalamadugus are exposed under the Paniams to the north and south of the road, there being no Banganapallis exposed; it would appear that here there has been no faulting. Thus the continuation of the Kalava wall west of the Kalava rest house would appear to be the site of a hinged fault, King's Gunnygull fault, with no throw south-east of Palakolanu, but a throw of some 300 feet or so to the north at its western (Ramallakota) end. There is thus a striking similarity between the western part of this 'sympathetic' post-Kurnool movement and the same part of the pre-Kurnool Ramallakota-Gani fault, always remembering that the pre-Kurnool movement was many times greater than the post-Kurnool movement.

Kalava wall from Kalava rest house to Chennakkapalle.

The similarity is not so marked when the eastern parts of both movements are considered. However, the Kalava wall proper, extending from the rest house to the village of Chennakkapalle, is by far the most interesting and most deserving of inspection. The series of sections shown in Plate 26 show the structure of the 11 miles of country to Chennakkapalle where the wall once again becomes an erosion scarp. The lines of section are also shown on Plate 26. All sections run from the low ground north of the wall, where the Kundairs crop out, to the higher plateau to the south, which is formed of Banganapalli sandstones capping the older Tadpatri shales and intrusive trap sills. The younger members of the Kurnool series have been removed from above the Banganapalli here.

Explanation of sections.

In figure 1, the Paniam quartzites of the wall overlie Jammalamadugu limestones and Banganapalli sandstones; and the last unconformably overlie the Tadpatri shales. Slipping has taken place at the monoclinal fold, but not to any appreciable extent. The main dislocation appears to have taken place nearer to the plateau, presumably, also, along the limb of a monoclinal fold which developed into the Somayajulapalle fault (*see* p. 447).

In figure 2, the monoclinal fold of the wall is more steep and irregular. The main dislocation is a short distance south-east of the wall, where the Tadpatris are very highly crushed. The original

crushed covering of Kurnool rocks above this dislocation, the Somayajulapalle fault, has been removed by erosion.

The main fault is very near the wall in figure 3. The Paniam quartzites are faulted against the Tadpatris, and there is no evidence on the surface of the existence beneath them of the older Jammalamadugus and Banganapallis, though they must, of course, be present.

Figure 4 shows an interesting variant in that there appear to have been at least four monoclinal folds, the two most important being that forming the wall, and that nearest the plateau of Kommucheruvu Motu. This section may be contrasted with figures 7 and 8, where there is but one monoclinal fold.

In figure 5, the folding is more dome-like and the Banganapallis form a large outcrop. A little slipping probably took place along the wall, but the major dislocation occurred close to the plateau along the limb of a monoclinal fold.

In figure 6, a large dislocation is shown at the wall, where the Paniam quartzites are faulted against the Tadpatris. There is here but a remnant of the large spread of Banganapallis seen in figure 5. Another dislocation took place along the limb of the monoclinal fold near the Chintalacheruvu plateau.

In figure 7, as in figure 8, the main fault is shown at the quartzite wall, where the Paniams are again faulted against the Tadpatris.

Figure 8 is very interesting. The high hill of Peddagummani Konda (1,562 feet) is not capped by any of the younger Kurnool rocks. It is higher in elevation than the Chintalacheruvu plateau to the south. The main fracture thus undoubtedly occurred along the wall where the Paniams are in juxtaposition with the Tadpatris. It is not to be wondered at that the monoclinal fold gave way under the stresses which such conditions must have entailed.

As shown in figure 9, the main dislocation, strangely enough, appears to have been double in character not far from the last locality, being partly along the wall and partly nearer the plateau. Evidence for this is given by the occurrence of a small outcrop of Banganapallis on the shoulder between Peddagummani Konda and Chinnagummani Konda (1,464 feet). The conditions pertaining at Chinnagummani Konda appear to be similar to those at Peddagummani Konda, as shown in figure 8, the main fault being at the site of the wall.

The existence of older faults, among which is the pre-Kurnool Ramallakota-Gani fault referred to previously, further complicates

the structure of the eastern part of the wall as seen in figures 10 to 13. Figure 10, however, differs but little from figures 7 and 8, but has been inserted for comparison with figure 11, that of a section a furlong or so further east.

The Pulivendla quartzites and Vaimpalli limestones referred to in the text are shown in figure 11; and under the latter, the Gulcheru quartzites. The downthrow of the old Ramallakota-Gani fault is shown as being to the south. Here again there is conclusive evidence that the main post-Kurnool dislocation took place along the wall, where the Paniam quartzites are faulted against the very much older Vaimpalli limestones.

Figure 12 has many points of resemblance to the last, but the Pulivendla quartzites are absent.

The last figure (fig. 13) is interesting as it shows the Banganapallis resting unconformably on the Pulivendlas, and because the Kalava wall has once again become merely an erosion scarp.

Somayajulapalle fault.

Reference has been made to the Somayajulapalle fault on page 445. It has been found necessary to postulate the existence of this post-Kurnool fault in order to explain the structure south and south-west of Kalava. The Paniam quartzite scarp from the rest house to the beginning of the Gunnygull dislocation, near Chintalapalle is unimportant. The main dislocation appears to be between the wall and the plateau to the south-east, running more or less N. E.–S. W. through the village of Somayajulapalle. It joins the Kalava wall near the location of figure 3 in Plate 26. Its south-westward continuation cannot be followed to any great distance. The throw of the Somayajulapalle fault near the village is about 500 feet to the north; that at the Kalava wall must be well over 1,000 feet.

Throw of the post-Kurnool movement.

It will have been noted that in all cases, both to the west and east of the Kalava rest house, the downthrow of the post-Kurnool movement responsible for the formation of the Kalava wall, the Somayajulapalle fault and the Gunnygull fault is to the north. Whilst this agrees with that of the western end of the Ramallakota-Gani hinged fault, it differs from the throw of the eastern end of that fault, which is to the south. Enough has been stated to show that the throw of the post-Kurnool movement varies greatly in amount and in position. In certain places, as at Peddagummani Konda, the movement is all concentrated at the wall, and must be of the order

of at least 1,600 feet, assuming a total thickness of the Kurnools of only 1,000 feet. In other places, the wall is but an erosion scarp and the chief movement took place elsewhere.

Conclusion.

The author ventures to think that the above, necessarily concise, account of the Kalava wall indicates that structure to be the result of post-Kurnool movement, more or less along the line of an old, pre-Kurnool, line of weakness; and that the movement has been chiefly faulting, or slipping, along the limbs of monoclinal folds.

EXPLANATION OF PLATE.

PLATE 26.—Geological sketch map of parts of the Dhone, Kurnool, Nandyal and Nandikotkur taluks of the Kurnool district, Madras Presidency, showing the Kalava wall of Paniam quartzites; with thirteen sections along lines indicated in the map.

THE TALC-SERPENTINE-CHLORITE-ROCKS OF SOUTHERN MEWAR AND DUNGARPUR. BY P. K. GHOSH, M.SC. (CAL.), D.I.C., D.SC., (LOND.), *Extra Assistant Superintendent, Geological Survey of India.* (With Plates 27 and 28.)

INTRODUCTION.

This paper embodies the results of an investigation on a group of ultrabasic intrusives which are abundantly developed in the southern part of Mewar (Udaipur State), as in the neighbourhood of Rikhabdeo (24° 5′: 73° 41′) and Kherwara (23° 59′: 73° 36′). Similar rocks were found by Mr. C. S. Middlemiss in the eastern part of the Idar State, and by the late Mr. N. D. Daru in the Dungarpur State. Middlemiss describes them as 'magnesian rocks'[1]; but as a mineralogical name, rather than a chemical one, better describes the characters of the rocks concerned, the writer prefers to use the term 'talc-serpentine-chlorite-rocks', as these minerals are the most dominant and characteristic constituents. The minerals are not, however, present in the same proportion, nor are they simultaneously developed in all the localities. According as there is an admixture of chlorite with talc or serpentine or both, the resulting rock may be called talc-chlorite-, serpentine-chlorite- or talc-serpentine-chlorite-rock, respectively. On the whole, the rocks of the northern part of the area have a distinct tendency to be enriched in chlorite with a corresponding diminution or the almost complete lack of the other two minerals, while those to the south are characterised by a higher content of talc and serpentine, the amount of chlorite showing a proportionate fall.

In Mewar, these rocks were first found by Dr. A. M. Heron, who with Mr. B. C. Gupta commenced mapping them. The writer brought the surveys of both into completion and his remarks are based chiefly on the rocks of Mewar.

DISTRIBUTION.

The distribution of the rocks in the southern (Dungarpur State),[2] and central areas (Parshad-Rikhabdeo-Kherwara-Barna area)[3] are

[1] *Mem. Geol. Surv. Ind.*, XLIV, pp. 99-109, (1921).
[2] From the original map of the Dungarpur State, by N. D. Daru.
[3] From the original map of Mewar by A. M. Heron, B. C. Gupta and the writer.

shown on the accompanying map (Pl. 28). The occurrences to the west of the above areas have already been recorded by Middlemiss in his memoir and the relevant map of the Idar State,[1] and hence are not shown here. Only the occurrences, further north in Mewar, which have been mapped by Heron and which are in the course of publication, have not yet been shown they occur intermittently along a N. N. E.-S. S. W. zone between the village which is three miles south of Khankhat (24° 23′ : 73° 29′) and Sempala (24° 49′ : 73° 37′). There are roughly four outcrops, *viz.* –(1) to the west of Khankhat; (2) in the valley running N. N. E. from Undithala (24° 35′ : 73° 32′); (3) between three miles N. N. E. of Bagrunda (24° 41′ : 73° 34′) and two miles east of Gogunda (24° 15′ : 73° 31′); and (4) at Sempala.

PHYSICAL CHARACTERS.

The rocks are all some shade of green in colour, varying between pale sea green to deep green and greenish-black. In hand-specimens, they are generally aphanitic, but sometimes titanite, garnet, octahedra of chromite and magnetite, crystals of amphibole, and (rarely) phlogopite associated with dolomite or calcite, are discernible in the compact and finely crystalline groundmass. The rocks are seldom massive, and share with the adjacent country-rock the characters impressed by pressure; thus, cleavage and schistosity are abundantly developed. The rocks have also undergone faulting as specimens with slickensided surfaces are obtainable. In some of the dense types, fine laminations have been produced, with crystals of titanite arranged in parallel rows. This is really an effect of pressure due to which the porphyroblasts of titanite are arranged parallel to the lamination of the rock. Weathering produces a pitted surface, and occasionally reddish spots in an otherwise greyish green groundmass.

Associated with these are occasional bands of coarse-grained rocks which may have a definitely banded or intergranular texture. These coarser types are composed of a dark green or brown hornblende, or a lighter coloured tremolite and actinolite associated with calcite.

Metamorphism of the original rock has also produced steatite in workable amounts (as at Rikhabdeo), also serpentine, actinolite-

[1] *Loc. cit.*

and tremolite-schists containing calcite and chlorite, impure dolomitic rocks, magnesite and a little asbestos.

Mention may here be made of the occurrence of veins of a fine-grained, often sheared and granulated, and partially kaolinised, tourmaline-granite in the body of the talc-serpentine rocks, as well as in the phyllites in the neighbourhood of Rikhabdeo and Barna (23° 58′: 73° 41′) where talcose and serpentinous rocks are most prevalent. In the field, it is often difficult to distinguish the granite from the talc-serpentine-rocks as it also has been rendered green by the abundant development of chlorite, and the highly comminuted nature of the constituent minerals renders their identification in hand-specimens extremely difficult. Under the microscope, however, it is found to be composed of a highly granulated aggregate of quartz, orthoclase, microcline, and a little plagioclase, abundant chlorite (which is derived from biotite) with inclusions of rutile, a little sericite, little grains of brown tourmaline, apatite. zoisite and ilmenite. Shear-zones are developed in the rock, and mortar-structure is also developed.

MODE OF OCCURRENCE, STRATIGRAPHICAL RELATIONS AND AGE.

Middlemiss discusses the stratigraphical relations of these rocks in Idar, and describes them as being constantly associated with the Delhi quartzite, 'in apparently bedded or banded masses or layers',[1] and ascribes them to the Delhi system. But recent mapping, carried southward from the clear sections in Mewar and Ajmer-Merwara, shows that the quartzites with which the magnesian phase is associated in Idar, really belong to the Aravalli system, and are below the base of the true Delhi quartzites. As they have not been found in the true Delhis, they may be presumed to be pre-Delhi in age.[2]

Middlemiss also discusses the possibility of these rocks being a locally developed sedimentary deposit; but as 'tremolite or actinolite, besides being found with calcite as a definite layer, also wanders away and pervades the quartzite above in irregular veins'[3] in Idar, and 'the magnesian minerals occupy narrow bands cutting

[1] *Loc. cit.*, p. 103.
[2] General Report for 1930 in *Rec. Geol. Surv. Ind.*, LXV, p. 142, (1931).
[3] *Loc. cit.*, p. 103.

indiscriminately into the Delhi (*i.e.*, Aravalli) quartzite and phyllite series'[1] in the Dungarpur State, he is inclined to think that 'their first appearance of being original sedimentary deposits interbedded with the Delhi (*i.e.*, Aravalli) Quartzite' is deceptive, and that they may be 'really adventitious in some way ....' *e.g.*, vein-fillings along a fissure or gaping in the quartzite He also says, 'it may be that the whole phenomenon is more of the nature of a normal peridotite intrusion, accompanied by the usual secondary changes of such rocks to serpentine, talc, magnesite and dolomite.'[2]

In Mewar, there is ample evidence of these rocks being intrusive and their mode of intrusion seems to be dyke and sill-like, as will appear from the following descriptions.

DESCRIPTION OF OCCURRENCES.

Exposure in the Som valley.

A junction of this rock with the Aravalli phyllites is exposed along the Som valley at Kagdar (24° 3′ : 74° 40′). Here the junction is conformable to the schistosity of the country rock (Aravalli phyllite) and both dip 45 to the east. No transgressive offshoots of the ultrabasic rocks were noticed. Near the junction, schistosity, which has also been developed in the talc-serpentine-chlorite-rock, is parallel to that of the surrounding country-rock; but inwards, this secondary structure is absent, and in the centre of the mass, joints, which are peculiar to a cooling igneous body and divide it into cubical and rhombohedral blocks, are present in great number. In the marginal regions coarse-grained actinolite-calcite and tremolite-calcite-rocks are found to occur in bands which are more or less parallel to the schistosity of the country-rock as well as that of the talc-serpentine mass. It has the appearance of a concordant dyke-like intrusion, but the apparent concordance may be deceptive; for, whatever, might have been the original nature of the boundary between the two formations, that is to say, whether the rock intruded parallel or obliquely to the original bedding and folds of the phyllite, all traces of that primary structure have been completely obliterated by the later forces which threw the whole region into north and south folds, and which also produced parallel planes of cleavage and schistosity in the constituent rock formations.

[1] *Ibid.*, p. 103.
[2] *Loc. cit.*, p. 106.

At this locality, the rock is injected by narrow veins of a banded hornblende-rock, consisting almost entirely of brown and greenish-brown hornblende crystals with small grains of opaque iron-ore, and a little plagioclase occurring along the margins. Ilmenite, changing to leucoxene, and small crystals of plagioclase are found as inclusions in the hornblende (*see* Pl. 27, fig. 1).

Here also it is found to occur in the midst of phyllites and to 'finger' out into the country-rock. Its mode of intrusion seems to be sill-like. In the east and west valley, $1\frac{1}{2}$ miles south-east of Kotra (24° 5′ : 73° 44′), the junction of the talc-serpentine-rock with the Aravalli phyllites is exposed; the plane of junction is more or less horizontal. The former is seen to be resting horizontally on the surface of the latter, the planes of schistosity of which dip at a high angle.

Occurrence two miles west of Rikhabdeo.

The talc-serpentine-rocks attain a maximum thickness of 50 to 60 feet and form the crests of the hills, whilst the bottom of the valley is formed by phyllite. Southwards (as in the north and south valley running through the mass, south of the first valley) no phyllite is exposed beneath the talc-serpentine-rock, although the levels of the two valleys are practically the same. On the other hand, it is seen to be overlain at the extreme south by rocks of the phyllite series, the planes of schistosity of which have practically the same dip as that of the phyllite underlying the mass to the north. Thus it seems that this intrusion is a sill, the floor of which is exposed to the north and the roof to the south, and that the phyllites under mountain-building forces of post-Aravalli times, behaved as a highly plastic mass while the talc-serpentine-rocks, being more resistant to deformative processes, withstood folding movements to a greater extent and thus appear as a more or less horizontal layer in the highly folded and foliated country rock. Towards the north, the mass becomes very narrow and wedges itself into, and finally cuts through, a band of limestone. As a result of contact metamorphism, the phyllites in the neighbourhood of this intrusion assume a red colour due to the oxidation of the ferrous iron into the ferric state.

This little mass of talc-serpentine-chlorite-rocks is lenticular in shape and occurs in the Aravalli phyllites. This occurrence is interesting from the point of view of its containing ellipsoidal inclusions of a dark bluish quartzite and recrystallised Aravalli limestone. This

Occurrence one mile W. N. W. of Kotra.

clearly proves the igneous origin of the talc serpentine-chlorite-rocks.

Under the microscope, the bluish quartzite is seen to be composed of granules of quartz, containing minute dust like inclusions and abundant grains of magnetite. A little calcite is present interstitially. The limestone is found to be composed of abundant calcite and a little opaque iron-ore, the latter sometimes enclosing radial aggregate of talc. A small amount of serpentine, sometimes associated with grains of opaque iron-ore, is also present.

Occurrence at Rikhabdeo.

This is a fairly large mass, in fact, the largest in Mewar. The country-rock is Aravalli phyllite. Near the margin, schistosity, which is parallel to that of the country-rock, is well-developed. Inclusions of phyllite, quartzite and limestone, some of them in long narrow bands, are common.

The quartzite inclusions assume a violet to purple colour and are found, under the microscope, to be composed of an aggregate of quartz in granular form, showing undulatory extinction, often charged with purplish dust-like inclusions (probably hæmatite); a few flakes of hæmatite and wisps of chlorite occur in the interspaces.

The limestones are thoroughly recrystallised, and are found, microscopically, to be composed chiefly of grains of calcite; sometimes of calcite in association with acid plagioclase, grains of quartz, a little chlorite and sericite.

In the marginal area, the talc-serpentine-chlorite-rocks tend to be talcose; workable quantities of steatite of a greyish green colour are developed in this mass, half a mile to the south-west of Rikhabdeo. Veins of a sheared tourmaline-granite are associated with this mass.

About one mile to the west of Rikhabdeo, an interesting modification of this rock is developed in the hill marked 1,604. Along the western margin of the outcrop, the rock becomes finely laminated, with opaque white crystals of titanite arranged parallel to the planes of lamination. Weathering has produced an extremely pitted surface in this rock.

Under the microscope, it is seen to be composed chiefly of chlorite and a little talc in which are embedded specks of colourless plagioclase, porphyroblasts of titanite with well-developed crystal-faces, and zoisite. There are also veins of chlorite passing through the larger crystals of titanite (*vide* Pl. 27, fig. 2).

In the neighbourhood of Barna (23° 50′: 73′ 41′) there are several outcrops of talc-serpentine-rocks. Their field-relations are practically the same as those of the rocks already described.

Deposit at Barna.

This area is interesting from the point of view of the contact metamorphism undergone by the country-rock. Thus, the phyllites have, in part, become mica-schists with an abundant development of rutile. In many localities along the Som valley, the country-rock yields rutile crystals, sometimes half an inch to one inch in length. The limestones associated with the talc-serpentine-rocks are highly metamorphosed and show the development of phlogopite, actinolite, etc. Thus a specimen of a limestone inclusion from half a mile north-west of Oda (23° 57′: 73° 42′) is seen to be composed of blades of tremolite, often containing poikilitic inclusions and intergrowths of abundant calcite and patches of opaque iron-ore. The limestone adjoining the talc-serpentine-rock at Dhelana (23° 58′: 73° 46′) shows the development of phlogopite.

Daru's map of the Dungarpur State shows that these rocks extend from the extreme north-west to the south-east of the State. They occur in the Aravalli phyllite, associated with quartzite or not, and are often interbanded with impure limestone. Daru mentions in his Progress Reports (for the field-seasons 1911-12 and 1912-13) that although the strikes of these rocks are usually conformable to the schistosity of the phyllites, there are sometimes found narrow tongues of these rocks running across the schistosity of the country-rock. Daru therefore advocates an igneous origin for these rocks.

Dungarpur deposits.

They are mostly talc-serpentine-rocks with little or no chlorite. Occurrences of quartz veins cutting through these rocks are noted by Daru. Asbestos is recorded near Dewal (23° 55′: 73° 40′). Actinolite, epidote, aragonite and magnetite are mentioned as being sometimes associated with these rocks. Workable quantities of talc-schist are reported from near the hill marked 1,152, *i.e.*, the hill two miles south of Jakol (23° 55′: 73° 49′).

The following paragraphs referring to the more northerly occurrences in Mewar are based on notes kindly supplied by Dr. Heron. This deposit is made up of 'chlorite-schists and calc-talc magnesian rocks, ... probably representing ultra-basic igneous rocks ......' They appear in the southern half of an anticline formed by the

Northerly occurrences in Mewar.

Deposit west of Khankhat.

Aravalli schists. 'The ultra-basic intrusives west of Khankhat are 200 to 300 yards wide and are poorly exposed except at their southern end, among the thick riverine boulder deposits of Recent or Sub-Recent age.' The magnesian rocks are concordant in strike with the quartzites and schists forming the country-rock.

Deposit north of Undithala.

'In the northern portion of the anticline (referred to above), that is north of the latitude of .... Undithala, igneous intrusives (*i.e.*, magnesian rocks) become more abundant, especially towards the centre. Along the central valley, which appears to correspond roughly with the axis, there is a line of magnesian (ultra-basic) rocks, consisting of chlorite- and talc-schists running for about six miles north from Undithala ....'

Deposit N. N. E. of Bagrunda.

'North-east of Bagrunda a narrow strip of magnesian rocks,—talc-chlorite- and tremolite-schists, runs along the west of the shreds of quartzite which represent the eastern quartzites of the anticline, when the quartzite finally dies out east of Gogunda, the magnesian rocks run for three miles further to the north, gradually widening towards their termination ....'

Deposit at Sempala.

'To the east of (the above), and parallel with it, running for four miles south from Sempala, is a much more extensive group of magnesian intrusions in two parallel belts connected at their south ends by an almost circular plug over half a mile in diameter. Both these belts have discontinuous and lenticular grey and black quartzites on the outside. To the west of Sempala is a very narrow bed of talcose limestone for two miles along the strike.'

MICROSCOPICAL CHARACTERS.

Under the microscope, no trace of the original ferromagnesian minerals is met with. Serpentine which is partly of the fibrous variety (antigorite) is associated with grains of iron-ore, minute flakes of talc, and sometimes chlorite. Talc seems to have been formed later than serpentine, as veins of talc pass through the serpentinous remains of the original minerals. Talc is almost always present and sometimes constitutes the whole bulk of the rock. It occurs either as aggregates of minute shreds or in stellate aggregates

as well as in very minute scales associated with iron-ores. It is also present as platy crystals with minute dust-like grains of opaque iron-ores along cleavage-planes. Associated with it are grains of calcite showing rhombohedral cleavage and aggregates of rutile, which are all embedded in a felted groundmass composed of scales and fibres of talc and chlorite. Sometimes crystals of zoisite are also present.

Locally, chlorite is developed. It may be present in narrow blades or in minute scales and fibres, and also in radiating aggregates. Sometimes it is associated with calcite-grains occurring interstitially. A little opaque iron-ore may be present as inclusion. Sometimes, grains of apatite, ilmenite changing to leucoxene, a little sphene and garnet are observed in the chloritised varieties.

The amount of iron-ore is variable; from small isolated grains, occurring sparsely, it is found as abundant dust-like aggregates along the cleavage planes of talc as well as in segregation patches of fair dimensions.

Actinolite- and tremolite-schists which are often associated with the talc-serpentine-rocks, especially along the margin of the bodies, and which represent an especially metamorphosed facies of the original rocks (*i.e.*, the rocks which give rise to the talc-serpentine-rocks) are seen to be composed chiefly of blades and stellate aggregates of actinolite or tremolite containing inclusions of iron-ores; calcite, a little quartz and sometimes a decomposed plagioclase, are present interstitially. A little chlorite is sometimes found.

ORIGIN OF THE MINERALS.

The rock which finally gave rise to the talc-serpentine-chlorite-rocks, was clearly an intrusive ultrabasic rock such as a peridotite or pyroxenite. Rocks similar in association to these talc-serpentine-chlorite-rocks, have been described by Merrill and Ries from different parts of America. Merrill says, describing the origin of asbestos in such rocks[1]:—

'The fibrous anthophyllite (asbestos) occurs along a slickensided zone between a schistose actinolite-rock and a more massive serpentinous or talcose rock which is presumably an eruptive peridotite or pyroxenite.'

[1] G. Merill, 'The non-metallic Minerals', 1st Edn., p. 183.

He further mentions:

'It is probable that in the fibrous form, the mineral is always secondary, and the fibrous structure due, in part at least, to shearing agencies.'[1]

It is quite possible that the asbestos of the Mewar deposits has had a similar origin, as there are evidences of slickensides and crushing in the neighbourhood of the asbestos localities, as well as in other places.

Referring to the origin of talc-deposits, Ries states[2]:—

'Talc is an alteration product of other magnesia minerals, such as tremolite, actinolite, pyroxene or enstatite, and is often associated with talcose or chlorite schists, serpentine and such basic igneous rocks as peridotite or pyroxenite. It is also associated with the older crystalline rocks. In some cases, it has, no doubt, been derived from an altered eruptive rock, but in others, probably from magnesian sediments, by metamorphism.'

In the case of the New York deposits, he maintains that the talc has been derived from the enstatite and tremolite of an altered impure crystalline limestone under the influence of water charged with carbonic acid.[3]

Summing up Peck's observations on an interesting case from New Jersey, Ries states[4]:—

'Talc occurs with serpentine in dolomite and near pegmatite intrusions. The latter, by contact metamorphism, developed tremolite, white pyroxene and phlogopite in the limestone. Later, during break-thrust faulting accompanying minor folding, squeezing and faulting in this area, the magnesian silicates were altered by water to talc and other products.'

Thus it seems that water charged with carbon dioxide and aided by faulting and folding movements, by its action on a suite of magnesian minerals or on a magnesia-rich rock composed of such minerals as magnesian pyroxenes and amphiboles, olivine, etc., may produce such rocks as those under consideration. The action may be explained as follows:—

$$\underset{\text{Enstatite}}{4(MgO.SiO_2)} + H_2O + CO_2 = \underset{\text{Talc}}{H_2O.3MgO.4SiO_2} + \underset{\text{Magnesite}}{MgCO_3}$$

$$\underset{\text{Tremolite}}{CaO.3MgO.4SiO_2} + H_2O + CO_2 = \underset{\text{Talc}}{H_2O.3MgO.4SiO_2} + \underset{\text{Calcite}}{CaCo_3}$$

$$\underset{\text{Olivine}}{4(MgO.SiO_2)} + H_2O + 5CO_2 = \underset{\text{Talc}}{H_2O.3MgO.4SiO_2} + \underset{\text{Magnesite}}{5MgCO_3}$$

It is evident from the above, that amongst the talcose products, one is likely to find calcite, magnesite and dolomite-minerals which

[1] *Ibid.*, p. 186.
[2] H. Ries, 'Economic Geology', p. 407, (1925).
[3] H. Ries, *op. cit.*, p. 408, (1925).
[4] *Ibid.*, p. 409.

are quite common in the Mewar deposits. When the pyroxenes, amphiboles and olivine contain iron, titanium and chromium in addition, minerals such as magnetite, rutile, ilmenite, titanite and chromite will appear on the decomposition of the parent minerals. Such products are abundantly disseminated through the talc-serpentine-rocks of Mewar.

Serpentine, chlorite and zoisite, being the usual decomposition products of basic and ultrabasic rocks, also appear in varying quantities in the rocks under discussion.

SEQUENCE OF METAMORPHIC PROCESSES.

There had been at least two types of metamorphic agencies at work on the parent rock before it was converted into talc-serpentine types and associated schists, *viz.* :—(1) chemical, *i.e.*, the action of water charged with carbonic acid ; and (2) mechanical, *i.e.*, the action of the folding, faulting and shearing stresses. The sequence of these two processes may be inferred from certain characters of the rocks. Mention has already been made of a variety of this rock in which crystals of titanite are found to have arranged themselves parallel to its planes of lamination. This shows that the formation of titanite had been complete, or almost complete, at the time the planes of lamination were produced in the rock, or in other words, that the chemical disintegration preceded the mechanical deformation.

Regarding the source of the CO_2-laden water, one naturally looks for it in the gases liberated during the consolidation of the intrusive rock. But whether the granite which is found occurring in the rock, as well as in the neighbourhood, has also contributed a share it is difficult to say. Considering the complete metamorphism of the original ferromagnesian minerals which character is common to both the ultrabasic rock and the granite, and also the kaolinised nature of the felspars of the latter, it seems probable that the decomposition was not wholly pre-granitic. The schistose nature of the granite proves that its intrusion took place prior to the advent of the compressional stresses which disturbed both the talc-serpentine-rocks and the granite.

ECONOMICS.

As mentioned before, workable quantities of steatite, varying between greenish gray and greyish white as to colour, and of variable

quality, are found half a mile to the W. S. W. of Rikhabdeo (24° 5′ : 73° 41′). It occurs over an area of about a quarter of a square mile. Shallow abandoned quarries are present in the steatite zone.

The asbestos, being very small in quantity, is not of any economic value.

The talc-serpentine-rocks, owing to their frequently handsome green colour—pale green varieties are also seen—, and their softness rendering them easy to work, are extensively used in the district for decorative purposes, and for door-posts and lintels. They are in great demand for the local temples, both as decorative stones and for the purpose of making images and idols. At Khandmin (23° 57′ : 73° 39′) near Kherwara, in Udaipur State, there is a big quarry which supplies the local demand. According to Daru 'talc-schist or pot-stone' is quarried to some extent near Jakol (23° 55′ : 73° 49′), in Dungarpur State, and 'is used for making pots, images and ornamental parts of buildings'.

EXPLANATION OF PLATES.

PLATE 27, FIG. 1.—Hornblende-rock showing hornblende with cleavage planes. Along the margins are opaque iron-ore (black) and plagioclase (white). Microslide No. 22148. Ordinary light. (X 20).

FIG. 2.—Talc-chlorite-rock with small grains and porphyroblasts of titanite (showing two systems of cleavage). The groundmass is composed of talc and chlorite. There is a vein of chlorite cutting through a crystal of titanite (upper right-hand corner of the figure). Microslide No. 22149. Ordinary light. (X 20).

PLATE 28.—Sketch geological map (parts of sheets 45 H and 46 E) showing the distribution of the talc-serpentine-chlorite-rocks of South Mewar and Dungarpur. Scale, 1 inch = 4 miles.

ON THE AGE OF CERTAIN HIMALAYAN GRANITES. BY J. B. AUDEN, M.A. (CANTAB.), *Assistant Superintendent, Geological Survey of India.*

INTRODUCTION.

In October, 1932, a small pebble of granite was found in the 'Volcanic breccia' of Garhwal, which had been previously mapped by Middlemiss.[1] This granite resembles granite found *in situ* in the Arwa valley of the Central Himalaya.

The object of this note is to discuss the bearing of this resemblance on the age of the inferred parent granite.

This discussion perhaps appears disproportionately long considering the small size of the pebble, but more than one pebble, boulder bed and granite proved to be concerned.

'VOLCANIC BRECCIA'.[2]

The exposure of volcanic breccia, in which the pebble of granite was found, is at the confluence of a small *nala* with the Medi Gad, at Raitpur (29° 51′ : 78° 12′), in half-inch to the mile sheet 53 K/N. E.

Middlemiss places this breccia at the base of his 'Purple Slate' series, at the base therefore of the sedimentary sequence belonging to his 'Outer series'. The breccia at Raitpur lies abnormally above the Tal beds, and is itself overlain by the 'Inner Schistose Series' with its capping of gneissic granite.[3]

The real succession he gave as below. To it I have added a correlation with the rocks of the Krol belt between Solon and Chakrata.

Garhwal.	Krol Belt.
Tals.	Tals.
Massive limestone	Upper Krol limestone.
Purple Slates . . . . (Conglomeratic boulder bed in Purple Slates) . ?	{ Krol B (Red Shales). Krol A (Lower Krol imestone). Infra Krol. Blaini. Jaunsars.
Volcanic breccia . . . . ?	Mandhalis.

[1] *Rec. Geol. Surv. Ind.*, XX, p. 33, (1887).

[2] The term 'volcanic breccia' has been placed in inverted commas, because it is uncertain what the exact nature of the rock is. It is probable that Middlemiss would not have been so positive had he examined these rocks a few years later [*see Rec. Geol. Surv. Ind.*, XL, p. 233, (1910)]. I hope to discuss this question in another place.

[3] The modern cantonment of Lansdowne is built on this gneissic granite. Formerly the hill was called Kalogarhi.

The correlation of the lower part of the Purple Slates with the rocks of the Krol belt is uncertain. Along the Pauri track, E. N. E. of Raitpur, Upper Krol limestone, Red Shales, Lower Krol limestone and Infra Krol were all clearly recognisable. After this follow purple slates with bands of green slate, a thin conglomeratic boulder bed (distinct from the volcanic breccia), more purple slates and, finally, ripple-marked quartzites. These purple slates and quartzites are certainly to be matched with those found in the Jaunsars of the Solon-Chakrata area, and it is tempting therefore to correlate the thin conglomeratic boulder bed with the Blaini. I did not see the volcanic breccia in its normal position, but its assignation by Middlemiss to the base of the Purple Slates suggests analogy with the Mandhali boulder beds which appear to underlie the Jaunsars near Chakrata and Kalsi. The correct position of the Mandhalis is not yet fully understood. Oldham, Pilgrim and West have all tentatively correlated them with the Blaini and Infra Krol. If this is substantiated, it follows that a thrust must separate them from the overlying Jaunsars.

From the point of view of the present paper the exact correlation does not matter. It is safe to say that the volcanic breccia occurs at a horizon below the Krol limestones which is either equivalent to or older than the Blaini. The Blaini is now regarded as the same age as the Talchirs, which are Upper Carboniferous in age.[1] It was considered by Sir Thomas Holland to be Purana,[2] but Pilgrim and West have given cogent reasons for reverting to the original Talchir correlation made by Oldham in 1883.[3] No one has suggested an age younger than Upper Carboniferous.

It may be taken, therefore, that the volcanic breccia of Garhwal is not younger than Upper Carboniferous.

It follows that a pebble of granite which occurs in this volcanic breccia must be derived from a parent granite which can at the latest have been exposed to denudation in Upper Carboniferous times. The intrusion of this granite would probably have been earlier still.

THE PEBBLE.

In the hand-specimen this is seen to be a fresh fine-grained non-porphyritic granite, with quartz, feldspar, green ferromagnesian mineral and pyrites (specimen No. 44/543).

[1] *Mem. Geol. Surv. Ind.*, LIII, p. 131, (1928).
[2] *Rec. Geol. Surv. Ind.*, XXXVII, p. 129, (1908).
[3] *Op. cit.*, XXI, p. 130, (1888).

Its specific gravity is 2·63.

Under the microscope, the rock is seen to contain quartz, albite-oligoclase, chloritised biotite, pyrites, ilmenite, apatite, calcite (rock slice No. 22171).

Quartz and plagioclase are about equal in amount. The plagioclase gives maximum extinction angles perpendicular to (010) of 15°. Its mean refractive index is equal to or just below that of balsam; in one case very slightly above. The mean refractive index is always well below that of quartz. The mineral approximates to albite-oligoclase. It is generally turbid with slight saussuritsation.

The biotite has been almost completely altered to chlorite, with liberation of iron. Shreds of brown and more birefringent biotite are occasionally to be seen interleaved with the chlorite.

Pyrites, ilmenite and rare apatite occur. Calcite is found in considerable quantities in interstitial clusters and veins.

The rock may be called an *albite-oligoclase-granite.*

GRANITES IN THE ARWA VALLEY.

From Musapani, in the Saraswati valley, six miles north of Badrinath, to Ghastoli and up the Arwa valley, a great variety of granites and gneissic granites is found. The commonest type is a moderately fine-grained white granite, without parallelism of minerals, showing quartz, feldspar, muscovite, biotite and often abundant tourmaline. In addition there are glomeroplasmatic gneisses with clusters of biotite, gneissic granites, feldspar augen granites and abundant pegmatites with or without tourmaline. Along the Arwa valley, from near the west end of its west to east course up to the 16,300 foot base camp established by the Kamet Expedition in 1931, there are found porphyritic and non-porphyritic granites with prevalent green ferromagnesian minerals, and often with pyrites. It was the memory of these granites which at once at Raitpur suggested a relationship with the pebble found in the volcanic breccia.

Specific gravities of two specimens, one a green granite, the other a whiter, biotite-granite, are respectively 2·66 and 2·63.

Under the microscope, these granites are seen to contain abundant quartz and albite-oligoclase. Microperthite and anorthoclase also occur and may be prevalent. In slide 22062 there is microperthite with subordinate oligoclase, the latter occurring both as fresh crystals,

and in perthitic intergrowth with orthoclase. In 22061, microperthite is less common than albite-oligoclase, while in one slide of 22061 albite greatly exceeds anorthoclase in amount. Biotite is more common than muscovite, and is very generally chloritised, 22061. Tourmaline is seen in 22065 and 22061. In 22065 there is apatite. Sphene occurs in 22061.

These rocks vary from *albite-oligoclase-granite* to *adamellite*.

COMPARISON.

It is seen from the above descriptions that there is a close similarity between the pebble found in the volcanic breccia of Raitpur, and the granites found *in situ* in the Arwa valley. The closest similarity is with rock slice 22061. The striking feature is the prevalence in both pebble and *in situ* granite of sodic plagioclase.[1]

It may be concluded, therefore, that granites, similar to those found in the Arwa valley, were intruded before the Upper Carboniferous.

Hayden[2] describes the presence of fragments of granite in the Kuling series of Spiti and the Agglomerate Slate of Kashmir, and therefore ascribes a pre-Carboniferous age to the parent rocks. Mr. Wadia tells me that the pebbles he has seen in the Agglomerate Slate are of white gneissic granite, very similar to that of Hazara. Hayden goes on to say—

> 'It will be seen subsequently that at this period the Himalaya did not exist and this old granite must therefore be excluded from the term "Himalayan."'

He contrasts this old granite with other granites found in the Himalaya, which have been regarded as Cretaceous or Tertiary in age. It is here that there seems to be a discrepancy, because, on the accounts of Griesbach and Hayden, the granites of the Arwa valley must be correlated with these later granites, and, on the account given above, similar granites should be considered as belonging to a Palæozoic suite.

[1] It should be pointed out that the occurrence of albite-oligoclase is not peculiar to the Arwa granites or to those found north of the Himalayan axis. It occurs, often extensively, in the Hazara, Chor and Lansdowne granites. Megascopically, these latter granites, even when unfoliated, are markedly different from those in the Saraswati and Arwa valleys. Microscopically there seems to be a greater spreading of small crystals of primary mica, distinct from saussurite-mica, throughout the feldspars, than is found in the Arwa granites.

[2] 'Geography and Geology of the Himalaya', p. 219, (1907-08).

OTHER OCCURRENCES OF GRANITE.

Griesbach

Griesbach[1] describes the presence of younger granites cutting through the older gneisses and schists, and traversing the overlying rocks of the Haimanta system (Cambrian and ? pre-Cambrian). He states that the greater peaks of the Central Himalaya are all within the line of this granitic intrusion, citing those of Kamet, Mana and Badrinath. The Arwa valley lies within this line. He describes these rocks as containing muscovite, quartz and albite, with accessory minerals such as tourmaline, garnet and beryl. There can be no doubt that the Arwa rocks belong to this so-called newer granite suite of Griesbach.

He remarks that there is nothing to show that the later Himalayan granite of Kumaon and Garhwal is much younger than lower Palæozoic, but suggests that at least some of these granites are equivalent to those in the Hindu Kush which are intrusive into upper Cretaceous rocks. He finally favours the view that the granites were intruded not long prior to the extensive basic rocks of Hundes, which are Middle Tertiary in age.

Hayden.

In the Spiti area Hayden[2] describes a biotite granite with orthoclase in excess of plagioclase, which is intrusive into older Palæozoics. In Rupshu he mentions a similar granite which cuts Carboniferous and Permian schists, and must therefore be post-Carboniferous or possibly post-Permian.

In the provinces of Tsang and Ü in Tibet,[3] he describes three series of igneous rocks—

(1) A foliated biotite-granite associated with tourmaline-granite, intrusive into Jurassic rocks, and probably not older than Eocene. This is a continuation of the great granitic axis of the Himalaya.

(2) Series of basic dykes, possibly Eocene.

(3) The Kyi Chu hornblende-albite-sphene-granite, which is definitely not older than Upper Cretaceous.

In the 'Geography and Geology of the Himalaya', pages 218 to 220, Hayden summarises the known occurrences of granite as follows:—

(1) Pre-Carboniferous granite, found as pebbles in the Kuling conglomerate and in the Agglomerate Slate.

[1] *Mem. Geol. Surv. Ind.*, XXIII, p. 42, (1891).
[2] *Mem. Geol. Surv. Ind.*, XXXVI, Pt. 1, p. 98, (1904).
[3] *Op. cit.*, XXXVI, Pt. 2, p. 62, (1907).

(2) Gneissose granite, described in detail by Lieut.-General McMahon, and thought to be early Tertiary.

(3) Biotite-granite, tourmaline-granite, hornblende-granite, which are either late Cretaceous or Tertiary.

It is the biotite-granite which Hayden states occurs at Chamba, Chor, Lansdowne, etc.

Age.

This classification is open to question. Firstly, although Hayden states that the granites of Chamba, Chor and Lansdowne belong to his biotite-granite division, yet it is these granites which were described by McMahon, and which are so largely gneissic. Middlemiss [1] and West [2] have both shown the passage of massive unfoliated granite into gneissic granite, and it is probable that the biotite-granite and gneissic granite of Hayden's classification are different but intimately related modifications of the same magma. Secondly, the late Cretaceous or Tertiary age of all these rocks is not so definite as Hayden's account leads one to suppose.

It is true that McMahon was consistently in favour of a Tertiary age for the gneissic granites which he had examined. Middlemiss,[3] however, maintained that the Hazara granite, and probably also those of Chor, Lansdowne and Dudatoli, were pre-Triassic. McMahon [4] criticised these conclusions, without, in my opinion, adding support to his own assertion of a Tertiary age. The evidence adduced by both these authors was of a negative kind.

De Terra.

In an important memoir,[5] De Terra has given an account of his geological reconnaissance through Central Asia in 1927-28. In the western K'un-lun (p. 47), he has discovered two main occurrences of granite; that of the K'un-lun proper (his *Hauptkette*), and that of the Kilian range. These granites are intrusive into gneisses, schists and sediments of the Karakasch and Kilian series. The latter series is Upper Silurian in part. De Terra considers that the intrusions are of Lower Devonian age. It is noteworthy that they have been strongly affected by orogenic movements of late Palæozoic age, which have resulted in the formation of schistosity and lamination (*plattige*

[1] *Rec. Geol. Surv. Ind.*, XX, p. 138, (1887).
[2] *Mem. Geol. Surv. Ind.*, LIII, p. 53, (1928).
[3] *Op. cit.*, XXVI, p. 277, (1896).
[4] *Geol. Mag.*, p. 304, (1897).
[5] 'Geologishe Forschungen im westlichen K'un-lun und Karakorum-Himalaya', Berlin, (1932).

Absonderung) oriented in a N. W.-S. E. direction. The modern Kilian chain strikes almost due east-west. This N. W.-S. E. direction of Palæozoic structures may be compared with that found by Dr. Heron in the Kirana hills (31° 58′: 72° 45′) of the Punjab, to be mentioned later.

De Terra considers that the Tankse granite, of the Ladakh and Karakorum area (p. 113), is definitely unconnected with the late Cretaceous and Tertiary folding of the Karakorum, but was intruded in late Palæozoic times.

ARAVALLI DIRECTIONS IN THE HIMALAYA.

In favour of the pre-Triassic age, advocated by Middlemiss, for some of the granites intensive in ranges bordering the Peninsula, is the striking orientation of phenocrysts and of lenticular and linear structures [1] in the gneissic granite at Lansdowne. In fifteen observations over different parts of the granite, I found the range of direction varied from 35°–215° to 60°–240°, averaging N. E.-S. W.

Similar directions were observed in the tectonic elongation of pebbles in the Jaunsar conglomerates along the Palor river (30° 42′ : 77° 24′), which averaged 60°–240°. Fold-ripples in the Jaunsar phyllites at Shallai (30° 40′ : 77° 42′) varied from 80°–260° to 60°–240°. The schistosity of the quartz-schists in the Jaunsar series near Andra (30° 36′ : 77° 44′) strikes due N. E.-S. W. These Jaunsar rocks are possibly Devonian in age. Idioblasts of andalusite in a hornfels by the Ramganga river (30° 2′ 30″ : 79° 17′ 30″) were seen to be oriented in a 50°–230° direction. This last occurrence is interesting, because the hornfels is a product of metamorphism of the Dudatoli granite, which can almost certainly be correlated with that at Lansdowne.

This orientation is at right angles to the present axis of the Himalaya, and is the same as that of the Aravalli range. If the present Aravalli range be continued across the Gangetic alluvium, it is seen to meet the Himalaya between Chakrata and Naini Tal.

No orientation along Aravalli directions has been seen in beds higher than the Blaini. The Infra Krol and the Krol limestones are unaffected by it. Fold-puckers in the Lower Krol limestone were seen to be parallel to 120°–300°, that is, parallel to the axis of the Himalaya.[2]

[1] *Flaserige (lentikulare) Textur* and *Gestreckte (lineare) Textur*, Grubenmann-Niggli, 'Die Gesteinsmetamorphose', p. 456, (1924).

[2] Some of these fold-puckers are distinct from the fold-ripples in the Jaunsars which were mentioned above. They appear to be original sedimentation ripple marks that have offered avenues of relief to later stress.

Accepting the Blaini as Upper Carboniferous, it follows that the dating of this Aravalli orientation is not later than Carboniferous.

This N. E.–S. W. orientation was presumably connected with orogenic activity along the Aravalli axis. It may be remarked that the linear schistosity (*gestreckte Textur*) of the amphiboles in the calc-schists of the Aravalli range of Rajputana was found to be parallel to the axis of the range, 30°–120°. The felspar phenocrysts in the Erinpura granite, as, for instance, at 24° 39′ : 73° 15′ (corrected longitude), are similarly oriented. It is true that the Delhi rocks, to which these calc-schists belong, are pre-Cambrian in age, and owe their structures to an orogenic activity that was pre-Cambrian, but there is reason to suppose rejuvenation along this range.[1]

The Vindhyan rocks of Bundi and Karauli States are sharply folded and faulted in a N. E.–S. W. direction.[2] These movements were post-Bhander in age and altogether distinct from the earlier orogenics responsible for the structures in the Delhi rocks. The age of the Vindhyans is not definitely known, but reasons have been put forward to support the supposition that some of the series in the Vindhyan system may be Cambrian.[3] This would imply that some of the movements affecting the Vindhyans were Cambrian or later, and accords with the considerations advanced above for structures found in the Palæozoic rocks of the present Himalaya. The movements were post-Cambrian and pre-Permian.

Middlemiss[4] has also recorded the presence of structures in the Kumaon which are oblique to the modern axis of the Himalaya. Basic volcanic rocks, with interbedded quartzites and slates, show folding, cleavage and crushing along a north to south strike. He states :—

'The lines of disturbance, therefore, in *some* Himalayan rocks do not coincide with those of the Sub-Himalaya, nor with other Himalayan rocks, and must have been due to other and older directions of thrust.'

The 'Himalayan' rocks of Middlemiss and Medlicott are pre-Tertiary. The 'Sub-Himalayan' rocks are the Tertiaries.

Dr. Heron has kindly drawn my attention to the N. W.–S. E. strike of the Aravalli rocks found in the Kirana hills, Punjab.[5] He

[1] Fermor, *Rec. Geol. Surv. Ind.*, LXII, p. 391, (1929).

[2] Heron, *Mem. Geol. Surv. Ind.*, XLV, p. 169, (1922). Coulson, *Rec. Geol. Surv. Ind.*, LX, p. 185, (1927).

[3] Auden, *Mem. Geol. Surv. Ind.*, LXII, Pt. 2, (*in the press*).

[4] *Mem. Geol. Surv. Ind.*, XXIV, p. 125, (1890).

[5] Heron, *Rec. Geol. Surv. Ind.*, XLIII, p. 299, (1913).

states that the border folds along the south-east flank of the Aravalli range tend to splay out at their extremities to the east, while the central folds of the range continue undeflected in a N. E.–S. W. direction towards Delhi. There is no evidence of the splaying out of the border folds along the north-west flank of the range, which might have been used to explain the N. W.–S. E. strike of the rocks at Kirana. Alluvium covers all the intervening ground.

While the existence of structures showing N. E.–S. W., or Aravalli directions is of importance in the part of the Himalaya with which this paper is chiefly concerned, it is clear that elsewhere these earlier structures assumed different orientations. Both at Kirana, and in the Kalian chain, the earlier, Archæan and Palæozoic, structures occur in N. W.–S. E. directions, at right angles to those found in the Himalaya between Chakrata and Naini Tal, and at right angles to the Aravalli chain itself.

The important point is that signs of earlier orogenic activities are till recognisable in the present Himalaya, in structures which are often inclined to the axes of the later, Tertiary, chains. Both Palæozoic and Tertiary chains show regional variation in direction, but the directions assumed during the two eras are not everywhere coincident. It is this lack of coincidence which is of value in determining the relative ages of intrusions.

ARKOSES.

In connection with a pre-Triassic age for some of the Himalayan granites, may be mentioned the prevalence of arkoses in the Jaunsar series (? Devonian) and in the Tal series (almost certainly Mesozoic). The Jaunsar arkoses contain plagioclase feldspar and tourmaline, and the Tal arkoses, microcline feldspar and tourmaline.

It may be concluded that these arkoses were derived from erosion of granites. It is true that any extensive series of metamorphic granulites (para-gneisses), such as occurs between Josimath and Mana, would yield abundant microcline and plagioclase, and that the presence of feldpsar alone would not prove a granitic provenance. It is the joint occurrence of feldspar and tourmaline that suggests a granitic source for the Jaunsar and Tal arkoses. Further, pebbles of feldspar may frequently be seen in the Tals, which are too large to have been derived from granulites.

LATER, HIMALAYAN, STRUCTURES.

Pilgrim and West have described the thrust displacement of the Chor granite and its country rock of Jutogh schists, due to the Tertiary movements.[1] It is quite possible that the Lansdowne granite, with its associated phyllites and schists, is similarly a thrust mass, occurring as a *Klippe* on Subathus, Tals, Krol and underlying slates. Middlemiss hinted at this in 1887,[2] but condemned the idea with arguments that do not appear to be altogether sound. Whatever be the true explanation of the displaced situation of the Lansdowne granite, it is clear that subsequent Himalayan movements have greatly modified its position, as they did that of the Chor granite, without, however, altering the Aravalli orientation due to the original intrusion tectonics. The granites may be considered Himalayan, in the sense that they have been incorporated in later Himalayan structures, but it seems that they were not Himalayan in their original intrusive condition. This was what was claimed by Hayden for the parent granite of the pebbles found in the Kulings and the Agglomerate Slate.

CONCLUSIONS.

Summarily, the evidence may be put forward as follows:–

(1) In Tibet and the Hindu Kush there is indisputable evidence of late Cretaceous or Tertiary granites.

(2) In the Central Himalaya there is indisputable evidence of granites intrusive into the Carboniferous. These have been regarded as Tertiary, chiefly because of the existence of known late Cretaceous or Tertiary granites in Tibet, etc. A pebble, resembling some of the newer suite granites in the Central Himalaya, has been found in the volcanic breccia of Garhwal. The granite, from which the pebble at Raitpur was derived, must have been pre-Triassic. It is possible, therefore, that both the older and newer suites of granite in the Central Himalaya are pre-Triassic.

(3) In the border ranges, including Hazara, Chor, Lansdowne, Dudatoli, there are characteristic gneissic granites which

[1] *Mem. Geol. Surv. Ind.*, LIII, p. 128, (1928).
[2] *Rec. Geol. Surv. Ind.*, XX, pp. 34, 37, (1887).

were held by McMahon to be Tertiary, but by Middlemiss to be pre-Triassic. In the case of the Lansdowne granite, and the hornfels related to the Dudatoli granite, there are structures which accord better with Aravalli tectonics. Pebbles of gneissic granite, similar to the Hazara granite, have been found in the Agglomerate Slate. There is more evidence in favour of a pre-Triassic age for these rocks than for a Tertiary age.

It will be seen from the above discussion that there are a great number of uncertainties. But it seems definite that some, at least, of the granites of the Central Himalaya and border ranges closer to the Peninsula, which have been considered to be of Tertiary age, were originally intruded in pre-Triassic times and belonged to pre-Himalayan tectonics. These earlier granites are of diverse types, and are probably of more than one age.

TABLES OF PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, OF MINERALS AND METALS IN INDIA BY L. L. FERMOR, O.B.E., D.SC., A.R.S.M. M.I.M.M., *Director, Geological Survey of India*

INTRODUCTION.

In a paper [1] read in 1927 at Montreal, Canada, at the Second Empire Mining and Metallurgical Congress, Sir Thomas Holland advocated the desirability of a review of the mineral resources of the British Commonwealth of Nations, so that information should be available regarding the surpluses of mineral supplies in certain parts of the Commonwealth available to meet deficiencies in other parts, and so that the data might be accumulated necessary for the formulation of an economic policy with regard to the mineral industry. This paper [2] had already been submitted in draft form and discussed at a meeting of the Institution of Mining and Metallurgy in London earlier in the same year; and after discussion at Ottawa, a resolution[3], sponsored by Mr. R. E. Palmer, President of the Institution of Mining and Metallurgy, was passed by the Empire Congress referring Sir Thomas Holland's proposal to the Empire Council of Mining and Metallurgical Institutions for consideration by their constituent bodies. In his Presidential Address [4] to the British Association at Johannesburg in 1929, Sir Thomas Holland took up this problem in another aspect under the title of the 'The International Relationship of Minerals', in the course of which he developed the thesis that owing to their control over a very considerable proportion of the total mineral resources of the world, the British Empire and the United States could, by refusing to export mineral products to belligerent countries, prevent wars of long

[1] 'Proposed Review of the Mineral Resources of the Empire', *Proc. Second Empire Mining and Metallurgical Congress*, Pt. I—General, pp. 49-91, (1928).

[2] *Trans. Inst. Min. Met.*, XXXVI, p. 396, (1927).

[3] *Proc. Second Min. and Met. Congress*, p. 193.

[4] Supplement to *Nature*, 3rd August, 1932, pp. 187-194.

duration. Sir Thomas Holland, therefore, regarded his proposal for a review of Empire mineral resources referred to above as a proposal to supply the data necessary to 'facilitate a working agreement between the two great mineral powers that alone have the avowed desire and the ability to ensure the peace of the world'.[1] At the Third Empire Mining and Metallurgical Congress at Johannesburg in 1930, the Council announced[2] that they had reached decisions in regard to the scope and character of the proposed review of mineral resources and industries of the Empire and the conditions affecting their development. It was decided that each of the constituent bodies should form a committee to deal with the Government of its own territory, and the lines upon which the proposed mineral survey should proceed were laid down.

The suggestions that emanated from Sir Thomas Holland were eventually adopted by the Imperial Conference of 1930, which instructed the Imperial Economic Committee to give effect to the resolution embodying these aims. A special committee, entitled the 'Minerals Committee of the Imperial Economic Committee', under the chairmanship of Sir William Larke, was appointed to devise a common plan for the collection and subsequent correlation of existing information on the mineral resources of the Empire, and to the Geological Survey of India the duty of putting together the statistical data for this country was entrusted by the Government of India.

As these data, now that they have been collected, prove to be of great interest, it has been decided to publish them in tabular form, although they are admittedly incomplete, as an addition to the figures already published by this Department in its Annual and Quinquennial Reviews of the Mineral Production of India. The co-operation of the Department of Commercial Intelligence and Statistics is cordially acknowledged. In future years if the data concerning imports and exports of minerals and metals can be obtained in time, it is proposed to include the appropriate figures in the Annual and Quinquennial Reviews of Mineral Production of India. The form of each of these tables follows as closely as possible that adopted as the standard by the Minerals Committee of the Imperial Economic Committee.

[1] *Loc. cit.*, p. 194.
[2] *Proceedings.*

The following explanations to the tabular data are offered :—

Table I.—Mineral reserves.

Adequate information regarding mineral reserves is available only for coal, iron, bauxite, copper in the case of the Indian Copper Corporation, Ltd.'s Mosaboni mine, and the mixed silver-lead-zinc-copper-ores of the Burma Corporation, Ltd., at Bawdwin. In other cases, as for instance manganese-ore and magnesite, all that can be said is that the resources are far in excess of probable requirements for many years to come. The figures in the last two columns are additional to those shown under 'proved reserves'.

Table II-A.—Annual mineral production.

This gives the production, for the calendar years 1913, 1917, 1920, and 1926 to 1931, taken from the Annual and Quinquennial Reviews of the Mineral Production of India.

Table II-B.—Annual metal production.

This is compiled mainly from information kindly supplied by the various companies, and relates to the same years as Table II-A.

Table III and Table IV.—Imports and exports respectively of minerals and metals.

These statistics were supplied by the Director-General of Commercial Intelligence and Statistics, and relate to the *fiscal* years 1929-30, 1930-31 and 1931-32, the Indian official year being from April 1st to March 31st. They are extracted from the customs and shipping returns and give the countries to which exports go and from which imports come, but are admittedly not complete. In Table III the terms and in column 2 'kinds and grades' are chiefly those used in the Sea-borne Trade and Navigation Reports of British India.

Table V.—Consumption of minerals and metals in 1931.

In this table relevant data of production, imports and exports for the year 1931 are brought together, and the consumption of each deduced in so far as this is possible. In the final column

an attempt is made to show whether the Indian production *vis-a-vis* internal consumption yields a *surplus*, is approximately *sufficient*, or is *insufficient* for the present needs of India. From a study of this instructive table one can see in which of the mineral industries of India there is room for expansion for the supply of the internal markets of the country.

Table VI.—Smelting and refining facilities as at the 31st July, 1932.

These statistics have been supplied by the mining and smelting companies. The term mine smelter is applied in cases where the company is smelting its own ores irrespective of whether the smelter is close to or distant from the mine.

TABLE I.—*Mineral Reserves*

Ores and minerals	Kinds and grades	Year	Proved reserves	Probable resources	Potential resources
Aluminium-ore . . .	Aluminous laterite, containing not less than 50 per cent of alumina and not more than 10 per cent of silica	1931		[illegible] million tons	100 million tons
Coal	Gondwana coalfields .	1931	5,000 million tons of good quality, of which 1,500 million tons are caking coal	20,000 tons [illegible]	60,0[illegible] tons in [illegible] or over [illegible] thick [illegible]
			No allowance made	for loss in working	
	Tertiary coals [illegible]	1931			600 [illegible]
Copper-ore .	Indian Copper Corporation Ltd containing 3·25 per cent of copper	1931	6·1 [illegible] tons		
	Burma Corporation Ltd averaging 14 per cent of lead, [illegible] per cent of zinc, 5 per cent of copper and 16 ozs of silver per ton	1931	111,000 tons		
Lead-ore (*see* also Copper ore)	Burma Corporation Ltd averaging 25·5 per cent of lead, 15·[illegible] per cent of zinc, 0·76 per cent of copper, and 20·1 ozs of silver per ton	1931	[illegible]	[illegible]	
Iron-ore	[illegible] per cent of iron	19[illegible]		[illegible]	
Silver-ore (*see* Copper ore and Lead-ore)					
Zinc-ore (*see* Copper-ore and Lead-ore)					

ERRATA.

Page 476, columns 5 and 6, against Coal, *for* '20,000 tons' *read* '20,000 million tons' and *for* '60,000 tons' *read* '60,000 million tons.'

TABLE II-A.—*Mineral Production.*

1 Ores and minerals.	2 Kinds and grades.	2a Unit.	3 1913.	4 1917.	5 1920.
Abrasives	Corundum	Tons	416	2,071	210
	Garnet	"	6	..	20
Aluminium (*see* under Bauxite)					
Antimony-ore	Mostly stibnite	"	10 (lbs.)	130	20(lbs.)
Arsenic-ore	Mostly orpiment	..	..	No figures available	
Asbestos	Chrysotile and other kinds	Tons	..	148	1,818
Barytes	....	"	..	..	678
Bauxite	....	"	1,184	1,363	3,031
Bismuth-ore	Native bismuth	Lbs.	..	560	..
Borates	Borax	Cwts.	..	..	..
China clay	....	Tons	..	..	..
Chrome-ore	Chromite	"	5,676	27,061	26,801
Coal, coke and by-products	Bituminous non-coking and coking coal	"	16,208,009	18,212,918	17,962,214
	Coke:—				
	Soft (non-metallurgical)	"	..	No figures available	
	Hard (metallurgical)	"	..	No figures available	
	By-products: ammonium sulphate	"	..	No figures available	3,732
Cobalt	....	..	..	No figures available	
Copper-ore	....	Tons	3,810	20,108	28,167
Diamonds	....	Carats	116	18	85
Felspar	....	Tons	..	No figures available	
Fuller's earth	....	"	1,103	No figures available	
Gold (*see* under Metal Production)	Mostly auriferous reef, and some alluvial gold	..	..	..	.
Graphite	....	Tons	..	105	100
Gypsum	....	"	24,961	16,083	33,551
Iron-ore	Mostly haematite	"	370,845	413,356	558,005
Lead-ore	Galena mixed with a little zinc-and copper-ore	"	20,325	71,634	128,908
Magnesite	....	"	16,108	18,202	11,346
Manganese-ore	Chiefly braunite and psilomelane; some hollandite and pyrolusite.	"	815,047	590,813	736,439
Mica	....	Cwts.	45,422	40,908	46,952
Molybdenum-ore	Molybdenite	"	..	27	1
Monazite	....	Tons	1,235	1,940	1,641
Nickel-ore (*see* under Metal production—Nickel speiss).					
Nitrates (*see* under Potash minerals).					
Petroleum	Crude	Gallons	277,555,225	282,759,523	293,116,834
	Petrol, including benzene and dangerous spirit	"	..	No figures available	
	Kerosene	"	..	..	..
	Burning oil	"	..	..	..
	Fuel oil	"	..	..	..
	Pitch	"	..	..	..
	Heavy benzene	"	..	..	..

(*a*) Export figures only.

6 1926.	7 1927.	8 1928.	9 1929.	10 1930.	11 1931.
28	65	21	34	30	..
14	285	480	..	7	..
108	500	370	77	3	.
			No figures available		
58	68	156	318	33	6
2,311	1,719	3,096	3,750	6,797	5,654
4,956	4,310	14,667	9,044	2,514	..
..	48	82	88	112	42
..	4	15	7	..	..
18,548	22,983	18,783	16,657	19,116	23,365
38,382	57,207	45,455	49,565	50,684	19,913
20,999,167	22,082,836	22,542,872	23,418,734	23,803,048	21,716,435
515,665	608,612	689,002	(a) 2,281	(a) 1,282	..
29,628	42,445	56,533			
16,138	18,507	15,409	17,567	16,181	12,133
			No figures available		
9,508	5,010	18,060	76,836	123,749	158,636
69	113	824	1,627	1,321	680
		No figures available		67	334
3,456	2,718	3,394	3,094	4,431	2,058
..	..	..	..	..	..
No production	No production		39	No production	6
34,473	38,105	59,050	52,726	56,316	58,632
1,659,205	1,846,735	2,055,992	2,428,555	1,849,625	1,624,888
362,911	450,777	443,654	464,696	530,124	397,679
30,461	10,638	24,406	23,407	16,523	5,333
1,014,928	1,129,353	978,440	904,270	820,946	537,844
41,924	42,614	45,112	53,231	52,727	38,963
..	..	..	..	..	..
64	280	103	180	14	90
280,369,326	281,113,000	305,943,711	306,148,093	311,080,108	305,018,751
	No figures available		21,241,770	21,329,562	22,558,932
..	..	..	141,119,575	135,572,748	147,550,020
..	..	..	11,648,787	17,223,639	15,297,171
..	..	..	5,567,644	7,504,289	14,598,991
..	..	..	102,020	126,049	9,810
..	..	..	52,538,400	51,705,400	41,268,500

TABLE II-A.—*Mineral Production*—contd.

1 Ores and minerals.	2 Kinds and grades.	2a Unit.	3 1913.	4 1917.	5 1920.	6 1926.	7 1927.	8 1928.	9 1929.
Petroleum—*contd.*	Wax	Tons.	..	..	..		..	..	17,717
	Residuum	,,	..	..	..	..	..	..	11,918,913
	Batching and lubricating oil.	,,	..	..	..		..	..	8,696,510
	Other sorts.	,,	..	..	..	..	..	..	5,387,116
	Grease	Lbs.	..	..	..	..	..	..	..
Phosphates	Apatite	Tons	..	..	..	718	603	805	22
	Phosphates	..	..	..	..	..	..	..	..
Platinum (*see* under Metal production).									
Potash minerals	Saltpetre: Exports	Cwts.	301,692	516,374	300,374	98,830	123,018	89,570	91,708
	Do. estimated amount used in tea gardens	,,	..	..	..	14,000	10,000	5,000	6,000
Pyrites	....	Tons	..	..	..	..	..	..	291
Salt (excluding Aden)	Rock-salt	,,	161,183	180,967	209,839	146,671	170,718	155,353	178,302
	Sea, sub-soil, and lake-salt	,,	1,138,098	1,123,760	1,239,110	1,297,553	1,259,410	1,137,225	1,284,554
Silver (*see* under Metal Production).									
Talc	....	,,	2,695	7,820	3,681	9,073	5,053	5,530	7,217
Tin-ore	Cassiterite concentrates from alluvial gravels	,,	171	666	2,110	3,548	3,995	2,780	3,764
	Cassiterite from concentrates containing wolfram 43 per cent., cassiterite 57 per cent. approximately, from low-grade wolfram-scheelite-cassiterite-ore.	,,	..	..	..	..	..	(*a*) 120	(*a*) 371
Titanium minerals	Low-grade ore	,,	..	..	1,223	..	..	..	..
	Ilmenite	,,	..	..	..	4,286	17,800	25,307	23,670
Tungsten minerals	Wolfram concentrate	,,	1,088	4,542	2,346	1,484	1,160	622	1,068
	Wolfram from concentrates containing wolfram 43 per cent., cassiterite 57 per cent. approximately, from low-grade wolfram-scheelite-cassiterite-ore.	,,	..	..	..	..	..	(*a*) 91	(*a*) 280
Uranium minerals	Samarskite	Lbs.	386	67	330	..	..	..	..
Zinc-ore	Zinc-blende concentrates from lead-silver-ores	Tons	3,871	..	..	49,681	58,286	61,122	58,436

TABLE II-B.—*Metal Production.*

1 Metals.	2 Kinds and grades.	2a Unit.	3 1913.	4 1917.	5 1920.	6 1926.	7 1927.	8 1928.	9 1929.
Antimony	Antimonial lead with 77 per cent. lead, 21 per cent. antimony and 6-8 ozs. silver per ton.	Tons	..	..	..	1,057	503	1,241	1,200
Bismuth	Mostly native (*see* Form II-A, under Bismuth ore)	Lbs.	..	500	..	..	48	82	88
Brass	....	Tons	..	..	..	..	..	..	..
Copper	Copper, refined	,,	512	†	†	†	†	†	1,635
	Copper-matte average 41 per cent. copper, 35 per cent. lead and 70 ozs. of silver to the ton.	,,	..	..	..	11,441	11,872	10,078	11,303
Gold	....	Fine ounces.	505,761	574,293	499,008	384,158	384,272	376,003	363,860
Iron	Pig-iron	Tons	291,112	248,132	311,256	902,433	1,140,051	1,051,881	1,301,511
	Steel	,,	156,993	114,027	113,222	360,080	414,738	208,865	410,923
	Castings*	,,	17,536	2,256	31,775	70,818	87,925	47,462	43,598
	Ferro-manganese	,,	..	..	1,183	10,503	5,002	3,233	3,630
Lead	From ore and slag	Tons	5,858	10,062	28,821	53,273	..	..	79,033
Nickel-speiss	24 to 30 per cent. nickel, 16 to 10 per cent. copper and 34 to 28 ozs. silver per ton.	,,	..	..	..	..	1,032‡	2,033§	3,065‖
Platinum	....	Fine ounces.	58	4	†	†	..	..	..
Silver	....	,,	125,200	1,580,557	2,906,397	5,126,088	6,024,806	7,425,810	7,298,327
Tin	Block tin	Cwts.	3,650	2,818	3,266	..	†	..	..

* Made from pig-iron, and therefore not additional figures.
† No figures available.
‡ (24·64 per cent. Ni, 15·92 per cent. Cu and 3·4 per cent. Co and also 33·58 oz. Ag per ton).

(*a*) Estimated figures only.
§ (24·8 per cent. Ni, 15·2 per cent. Cu and 3·4 per cent. Co and also 32·2 oz. Ag per ton).
‖ (27·08 per cent. Ni, 13·16 per cent. Cu and 3·4 per cent. Co and also 30·08 oz. Ag per ton).
¶ (30·19 per cent. Ni, 10·43 per cent. Cu and 3·4 per cent. Co and also 28·88 oz. Ag per ton).
** (27·68 per cent. Ni, 10·75 per cent. Cu and 3·4 per cent. Co and also 32·32 oz. Ag per ton).

10	11
1930.	1931.
82,058	49,397
17,077,850	21,259,863
10,912,431	9,192,810
5,618,313	5,977,009
..	29,350
251	109
52	..
76,538	123,117
16,000	13,600
..	..
175,467	161,893
1,161,436	1,391,470
6,857	5,135
3,021	2,560
(a)1,250	(a)1,605
..	..
28,776	36,166
1,508	969
(a) 943	(a)1,279
..	..
57,620	51,455

10	11
1930.	1931.
1,700	1,505
112	42
712	3,637
2,974	4,069
17,140	13,487
329,232	330,489
1,175,202	1,058,386
427,035	439,184
87,986	60,971
4,576	14,336
78,030	73,280
3,150¶	2,911**
..	..
7,072,050	6,923,005
†	..

TABLE III.—*Imports of Minerals and Metals.*

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	BRITISH EMPIRE.																			
Aluminium unwrought (ingots, blocks, bars, etc.)	United Kingdom .	Cwts.	281	18,981	..	..	..	..	851	55,880	..	..	..	..	16	1,266	..	..	..	..
	Ceylon . . .	"	..	..	..	..	..	..	..	..	..	..	..	..	115	2,060	..	..	..	..
	Total British Empire .	"	281	18,981	..	..	..	..	851	55,880	..	..	..	..	131	3,326	..	..	..	..
	FOREIGN COUNTRIES.																			
	Italy . . .	"	99	6,186	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Germany . . .	"	..	..	..	..	..	..	..	..	..	..	..	..	10	695	..	..	..	..
	United States of America, *via* Atlantic Coast.	"	600	35,178	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Total Foreign Countries.	"	699	41,364	..	..	..	..	..	..	..	..	..	..	10	695	..	..	..	..
	GRAND TOTAL .	"	980	60,345	..	..	..	..	851	55,880	..	..	..	..	141	4,021	..	..	..	..
	BRITISH EMPIRE.																			
Arsenic and its oxides.	United Kingdom .	"	9	2,483	..	..	..	..	41	834	..	..	..	..	110	2,165	..	..	..	..
	Aden and Dependencies.	"	934	3,650	..	..	..	..	..	..	6	160	..	..	..	..	1	60	..	..
	Straits Settlements (including Labuan).	"	9	981	..	..	..	..	15	1,080	..	..	..	..	..	..	..	..	..	..
	Hongkong . . .	"	555	40,580	..	..	..	..	871	63,437	..	..	..	..	575	31,149	..	..	..	..
	Bahrein Islands . .	"	..	..	8	510	..	..	..	..	8	220	..	..	..	..	2	60	..	..
	Ceylon . . .	"	..	..	8	295	..	..	..	..	2	60	..	..	..	..	..	..	..	..
	Total British Empire .	"	1,507	47,703	16	805	..	..	927	65,360	16	440	..	..	691	36,314	3	120	..	..
	FOREIGN COUNTRIES.																			
	Maskat Territory and Trucial Oman.	"	..	..	..	..	..	..	..	..	1	10	..	..	..	..	..	..	..	..

1 Minerals and metals.	2 Kinds and grades.	3 Countries from which imported.
		FOREIGN COUNTRIES—*contd.*
Arsenic—*contd.*	Arsenic and its oxide—*contd.*	Germany . . .
		Netherlands . .
		Belgium . . .
		Italy . . .
		France . . .
		Syria . . .
		Spain . . .
		Other Native States in Arabia.
		Turkey, European .
		Iraq . . . .
		Persia . . .
		Java . . .
		China (exclusive of Hongkong and Macao).
		United States of America *viâ* Atlantic Coast.
		Siam . . .
		Total Foreign Countries.
		GRAND TOTAL .
		BRITISH EMPIRE.
Asbestos . .	Asbestos, raw .	Straits Settlements (including Labuan).
		FOREIGN COUNTRIES.
		GRAND TOTAL .

TABLE III.—*Imports of Minerals and Metals*—contd.

4	5						6						7					
	1929-30.						1930-31.						1931-32.					
Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Cwts.	186	3,324	..	..	..	..	282	4,311	..	..	..	..	390	7,298	..	..	..	..
"	20	301	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	598	11,835	7	600	..	..	448	8,241	..	..	..	..	460	8,735	..	..	..	..
"	..	..	..	..	..	..	..	..	..	..	..	..	16	3,174	..	..	..	..
"	24	2,998	..	..	..	..	11	1,725	..	..	..	..	..	..	..	..	..	..
"	..	..	3	150	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	5	1,461	..	..	..	..	..	..	..	..	..	..
"	..	..	1	25	..	..	..	..	..	..	..	..	..	..	3	156	..	..
"	15	4,261	..	..	..	..	28	3,504	..	..	..	..	26	5,440	..	..	..	..
"	51	2,570	..	..	..	..	..	..	..	..	..	..	15	690	..	..	..	..
"	..	..	1	25	..	..	81	1,566	17	675	..	..	60	1,928	2	60	..	..
"	..	..	9	332	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	712	50,741	..	..	..	..	470	33,823	..	..	..	..	403	22,847	..	..	..	..
"	1	47	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	..	..	3	120	..	..	..	..	..	..	..	..
"	1,607	76,077	21	1,182	..	..	1,275	54,601	21	814	..	..	1,370	50,124	5	245	..	..
"	3,114	1,28,780	37	1,937	3,077	1,21,843	2,202	1,20,051	37	1,254	2,165	1,18,797	2,001	86,438	8	365	2,050	86,078
"	33	263	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	33	263	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

3	4	5						6						7					
		1929-30.						1930-31.						1931-32.					
Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
		Quantity.	Value.	Quantity	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
....	Cwts.	32,055	2,40,360	..	..	..	..	127,630	3,19,105	..	..	..	..	54,862	1,73,658	..	..	..	..
....	,,	19,081	2,13,708	..	..	..	..	13,150	1,59,502	..	..	..	..	21,041	2,30,673	..	..	..	..
United Kingdom .	,,	498,362	15,10,209	..	.	..	..	239,217	7,05,850	..	..	..	..	391,137	9,05,058	..	..	..	..
FOREIGN COUNTRIES.																			
Germany . . .	,,	..	1	..	..	..	..	10	50	..	..	..	..	21	143	..	..	..	..
Belgium . .	,,	200	768	..	..		..	250	1,190	..	..	..	..	702	3,005	.	..	..	..
Austria . . .	,,	..	..	..	..	..	..	220	655	..	..	..	..	1,198	3,461	..	..	..	..
China (exclusive of Hongkong and Macao).	,,	..	..	..	..	..	..	..	..	..	..	..	..	16	105	..	..	..	..
Japan . . .	,,	..	..	..	..	..	..	40	466	..	..	..	..	..	..	..	..	..	..
United States of America—																			
Viâ Atlantic Coast .	,,	446	4,368	..	..	..	..	..	..	..	..	..	..	380	1,403	..	..	..	..
,, Pacific Coast .	,,	..	..	..	..	..	..	..	..	..	..	..	..	220	848	..	..	..	..
Total Foreign Countries.	,,	646	5,137	..	..	..	..	535	2,361	..	..	..	..	2,537	9,085	..	..	..	..
GRAND TOTAL .	,,	499,008	15,15,346	..	..	..	..	239,752	7,08,211	..	..	..	..	393,674	9,14,143	..	..	..	..
BRITISH EMPIRE.																			
United Kingdom .	Tons	18,812	3,78,495	..	..	..	..	23,245	4,78,393	..	..	..	..	23,760	5,55,930	..	..	..	..
Aden and Dependencies.	,,	..	..	..	..	..	..	326	4,748	..	..	..	..	155	2,825	..	..	..	..
Ceylon . . .	,,	800	3,300	..	..	..	..	854	11,860	..	..	..	..	710	12,780	..	..	..	..
Straits Settlements (including Labuan).	,,	175	1,766	..	..	..	..	678	12,876	..	..	..	..	9	162	..	..	..	..
British Borneo . .	,,	100	2,000	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hongkong . . .	,,	75	1,050	..	..	..	..	..	..	..	..	..	..	120	1,510	..	..	..	..

TABLE III.—*Imports of Minerals and Metals* contd.

1	2	3	4	5						6						7			
				1929-30.						1930-31.						1931-32.			
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Coal, coke and by-products—*contd.*	Coal and coke—*contd.* (a) Coal—*contd.*	BRITISH EMPIRE—*contd.*																	
		Federated Malay States.	Tons.	..	..	..	..	..	..	..	..	..	..	..	..	1,070	14,415	..	..
		Natal	"	197,404	36,36,747	..	..	..	..	121,033	21,42,554	..	..	..	..	23,211	3,99,919	..	..
		Transvaal	"	..	..	..	..	..	..	500	9,000	..	..	..	..	..	..	..	..
		Kenya Colony	"	..	..	..	..	..	..	..	..	..	..	..	..	720	10,800	..	..
		Western Australia	"	650	6,500	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		New South Wales	"	1,190	23,800	..	..	..	..	1,455	32,010	..	..	..	..	3,805	89,230	..	..
		Fiji Islands	"	128	1,300	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire	"	218,834	40,54,898	..	..	..	..	148,181	26,91,441	..	..	..	..	53,590	10,87,131	..	..
		FOREIGN COUNTRIES.																	
		I[illegible]q	"	..	..	..	..	..	..	271	5,120	..	..	..	..	..	..	..	..
		[illegible] Islands	"	118	2,124	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Other Native States in Arabia.	"	1,100	25,200	..	..	..	..	250	4,100	..	..	..	..	..	..	..	..
		Indo-China	"	..	..	..	..	..	..	..	..	..	..	..	..	600	12,000	..	..
		Java	"	1,769	26,162	..	..	..	..	1,035	15,280	..	..	..	..	352	3,737	..	..
		Spain	"	80	960	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		China (exclusive of Hongkong and Macão).	"	200	3,200	..	..	..	..	..	..	..	..	..	..	252	3,528	..	..
		Japan	"	1,151	20,205	..	..	..	..	950	15,900	..	..	..	..	826	16,410	..	..
		Egypt	"	224	3,360	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Portuguese East Africa.	"	150	3,300	..	..	..	..	5,001	96,154	..	..	..	..	..	..	..	..
		Italian East Africa	"	300	5,400	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Total Foreign Countries.	"	5,392	89,911	..	..	..	..	7,507	1,37,154	..	..	..	..	2,020	35,675	..	..
		GRAND TOTAL	"	224,226	41,44,809	..	..	..	..	155,688	28,28,595	..	..	..	..	55,610	11,22,806	..	..

1	2	3
Minerals and metals.	Kinds and grades.	Countries from which imported.
		BRITISH EMPIRE.
Coal, coke and by-products—*contd.*	Coal and coke—*contd.* (*b*) Coke . .	United Kingdom .
		Straits Settlements (including Labuan).
		Natal . . .
		Total British Empire .
		FOREIGN COUNTRIES.
		Germany . . .
		Japan . . .
		Siam . . .
		Java . . .
		Total Foreign Countries.
		GRAND TOTAL .
		BRITISH EMPIRE.
	Pitch and tar— (*a*) Coal tar and pitch.	United Kingdom .
		Straits Settlements (including Labuan).
		Ceylon . . .
		Natal . . .
		Total British Empire .

TABLE III.—*Imports of Minerals and Metals*—contd.

4	5						6						7					
	1929-30.						1930-31.						1931-32.					
Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Tons	3,417	1,37,142	..	..	..	..	4,323	1,58,007	..	..	..	..	1,496	61,534	..	..	..	..
"	171	10,275	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	9,180	2,02,268	..	..	..	..	18,020	4,66,617	..	..	..	..	9,844	2,17,382	..	..	..	..
"	12,768	4,00,080	..	..	..	..	22,343	6,24,624	..	..	..	..	11,340	2,78,916	..	..	..	..
"	..	..	..	..	..	..	416	12,559	..	..	..	..	804	26,165	..	..	..	..
"	..	..	..	..	..	..	107	3,389	..	..	..	..	..	..	..	..	..	..
"	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
"	..	3	..	..	..	..	523	15,948	..	..	..	..	804	26,166	..	..	..	..
"	12,768	4,09,683	..	..	..	..	22,866	6,40,572	..	..	..	..	12,144	3,05,082	..	..	..	..
Cwts.	35,271	1,02,809	..	..	..	..	10,750	1,22,385	..	..	..	..	33,345	1,66,364	..	..	..	..
"	39	104	..	..	..	..	170	1,457	..	..	..	..	11	99	..	..	..	..
"	225	816	..	..	..	..	56	170	..	..	..	..	14	84	..	..	..	..
"	3	14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	35,538	1,03,743	..	..	..	..	10,976	1,24,012	..	..	..	..	33,370	1,66,547	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	FOREIGN COUNTRIES.																			
Pitch and tar—*contd.*	Russia—																			
(*a*) Coal tar and pitch—*contd.*	Northern Russia	Cwts.	..	..	..	..	..	..	..	..	..	..	..	..	58	531	..	..	..	..
	Southern Russia	"	..	..	..	..	..	..	..	..	..	..	..	..	60	531	..	..	..	..
	Norway	"	107	2,312	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Sweden	"	..	..	..	..	..	..	..	..	..	..	..	..	21	138	..	..	..	..
	Germany	"	73	1,194	..	..	..	..	33	850	..	..	..	..	290	3,535	..	..	..	..
	Netherlands	"	6	145	..	..	..	..	129	961	..	..	..	..	110	1,526	..	..	..	..
	Java	"	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..
	Japan	"	5,856	22,053	..	..	..	..	21,826	81,101	..	..	..	..	25,601	86,594	..	..	..	..
	United States of America *viâ* Atlantic Coast.	"	..	..	..	..	..	..	18	200	..	..	..	..	680	5,471	..	..	..	..
	Belgium	"	27	207	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Italy	"	15	387	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Other Native States in Arabia.	"	2	40	..	..	..	..	1	10	..	..	..	..	..	..	..	..	..	..
	Indo-China	"	..	..	..	..	..	..	..	..	..	..	..	..	8	52	..	..	..	..
	Total Foreign Countries.	"	6,176	26,338	..	..	..	..	22,007	83,230	..	..	..	..	26,837	98,982	..	..	..	..
	GRAND TOTAL	"	41,714	2,20,081	..	..	..	..	41,083	2,07,242	..	..	..	..	60,207	2,64,020	..	..	..	..
	BRITISH EMPIRE.																			
(*b*) Stockholm tar and pitch.	United Kingdom	"	3,211	48,820	..	..	..	..	1,844	26,752	..	..	..	..	2,070	20,032	..	..	..	..
	Ceylon	"	23	434	..	..	..	..	2	56	..	..	..	..	..	..	..	..	..	..
	Total British Empire	"	3,234	49,254	..	..	..	..	1,846	26,808	..	..	..	..	2,070	20,032	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	FOREIGN COUNTRIES.																			
Pitch and tar—contd. (b) Stockholm tar and pitch—contd.	Sweden	Cwts.	804	12,173	..	..	..	..	881	11,663	..	..	..	..	917	8,761	..	..	..	..
	Norway	,,	197	3,543	..	..	..	..	218	2,116	..	..	..	..	..	..	..	..	..	..
	Java	,,	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
	Germany	,,	..	..	..	..	..	..	211	2,146	..	..	..	..	125	1,256	..	..	..	..
	Indo-China	,,	..	..	..	..	..	..	..	..	..	..	..	..	2	24	..	..	..	..
	Total Foreign Countries.	,,	1,001	15,716	..	..	..	..	1,310	15,925	..	..	..	..	1,044	10,045	..	..	..	..
	GRAND TOTAL	,,	4,205	64,070	..	..	..	..	3,165	42,738	..	..	..	..	3,114	30,077	..	..	..	..
Copper— (a) Ore	United Kingdom	Tons	..	..	..	..	..	..	1	937	..	..	..	..	..	..	..	..	..	..
	FOREIGN COUNTRIES.																			
	Norway	,,	5,507	2,08,846	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	United States of America *vid* Atlantic Coast.	,,	..	..	..	..	..	..	1	157	..	..	..	..	..	..	..	..	..	..
	Total Foreign Countries.	,,	5,507	2,08,846	..	..	..	..	1	157	..	..	..	..	..	..	..	..	..	..
	GRAND TOTAL	,,	5,507	2,08,846	..	..	..	..	2	1,094	..	..	..	..	..	..	..	..	..	..
	BRITISH EMPIRE.																			
(b) Unwrought (tiles, ingots, cakes, bricks and slabs).	United Kingdom	Cwts.	12,025	7,36,083	..	..	..	..	8,623	4,53,441	..	..	..	..	2,900	1,20,505	..	..	..	..
	Ceylon	,,	100	7,298	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Total British Empire	,,	12,125	7,43,381	..	..	..	..	8,623	4,53,441	..	..	..	..	2,900	1,20,505	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6							
				1929-30.						1930-31.							
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
		FOREIGN COUNTRIES.															
Copper—contd.	Copper—contd.	Switzerland	Cwts.	..	..	..	..	..	..	..	..	.	.		.	..	12
	(b) Unwrought (tiles, ingots, cakes, bricks and slabs)—contd.	Germany	,,	..	..	..	..	..	..	178	7,870		.	.	..	70	3,267
		Persia	,,	3	150	..	..	..	..	..	..	..	..				..
		Portuguese East Africa	,,	..	..	..	..	..	..	587	25,884	.	.	.		.	..
		United States of America *via* Atlantic Coast.	,,	3,000	1,93,039	..	..	..	..	4,093	1,84,154	..	.			715	33,912
		Total Foreign Countries.	,,	3,003	1,93,189	..	..	..	..	4,858	2,17,908	..	.	.	.	785	37,191
		GRAND TOTAL	,,	15,428	9,86,520	..	.	..	..	13,481	6,71,349			.		3,715	1,57,606
	(c) Other sorts	United Kingdom	,,	..	45	..	..	..	..	2	456	.	..		.	..	..
		Germany	,,	123	8,134	..	..	..	..	1	89	.	..	..	.	..	..
		GRAND TOTAL	,,	123	8,170	..	..	..	..	3	515	..	..	.	.	.	.
	Copper unwrought (in Re-exports).	Sweden	,,	..	..	..	.	..	..	..	..	.	100	.	.	.	
		Belgium	,,	..	..	..	20	..	..	..	..		..	.			
		United States of America *via* Atlantic Coast.	,,	..	..	..	..	..	..	..	..	1	75			.	..
		GRAND TOTAL	,,	..	..	..	20	..	..	..	..	1	175	..	.	.	..
		BRITISH EMPIRE.															
Diamonds	..	United Kingdom	..	..	9,60,576	..	..	..	..	..	1,13,415	.	..	..	.	.	1,47,724
		Ceylon	..	..	2,929	..	..	..	..	..	880	..	..		.	.	936
		Straits Settlements (including Labuan)	..	..	3,95,648	..	..	..	..	.	31,243	.	..			..	1,379
		Natal	..	..	1,321	..	..	..	..	..	14,765	..	..	..	..	..	45,697
		Cape of Good Hope	..	..	..	..	..	..	..	..	..	..	..	..	..	..	58
		Total British Empire	..	..	13,60,474	..	.	..	..	..	1,60,303	..	..	..	..	..	1,95,053

7

1931 32

R export		Reclaimed Imports	
antity	V l	Quantity	Value
	R		Rs

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5 1929-30.						6 1930-31.						7 1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	FOREIGN COUNTRIES.																			
..	Germany	..	..	33	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Netherlands	..	..	8,11,923	..	..	..	..	..	4,39,792	..	..	..	..	..	1,20,031	..	..	..	..
	Belgium	..	..	65,87,055	..	..	..	..	..	39,14,989	..	..	..	..	..	28,60,467	..	..	..	..
	France	..	..	37,219	..	..	..	..	..	32,376	..	..	..	..	..	51,209	..	..	..	..
	Switzerland	..	..	4,680	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Macao	..	..	..	..	..	..	..	..	467	..	..	..	..	..	..	..	..	..	..
	United States of America *via* Atlantic Coast.	..	..	..	..	..	..		..	6,050	..	..	..	..	..	..	..	..	..	..
	Total Foreign Countries.	..	..	69,40,951	..	..	..	.	..	43,93,671	..	..	..	..	..	30,31,707	..	..	..	..
	GRAND TOTAL	..	..	83,01,425	..	..	..	..	..	45,53,077	..	..	..	..	..	32,27,450	..	..	..	..
	BRITISH EMPIRE.																			
Gold—Bullion (bar, ingots and other kinds of uncoined gold).	United Kingdom	Fine ounces.	365,793	2,09,47,803	..	..	..	..	347,670	1,00,31,542	..	..	..	..	40,162	23,60,322	..	..	..	..
	Aden and Dependencies.	"	887	50,754	..	..	..	..	644	36,855	..	..	..	..	3,027	2,23,222	..	..	..	..
	Bahrein Islands	"	82	4,729	..	..		..	3,639	2,06,611	..	..	..	..	19,487	13,09,456	..	.	..	..
	Ceylon	"	3	225	..	..	..	..	7	375	..	..	..	..	52,618	36,34,113	..	..	..	..
	Straits Settlements (including Labuan).	"	7,900	4,53,634	..	..	..	..	124,073	71,27,106	..	..	..	..	4,248	2,83,382	..	..	..	..
	Hongkong	"	6,551	3,83,008	..	..	..	..	55,889	32,01,619	..	..	..	..	544	35,057	..	..	..	.
	Natal	"	284,014	1,62,23,462	..	..	..	..	303,326	1,73,96,174	..	..	..	..	..	..	..	..	..	..
	Zanzibar and Pemba	"	..	..	..	..	..	..	..	..	..	..	..	..	235	18,447	..	..	..	..
	Kenya Colony	"	..	..	..	..	..	..	..	..	..	..	..	..	2,719	2,06,310	..	..	..	..
	Anglo-Egyptian Sudan.	"	..	..	..	..	..	..	..	..	..	..	..	..	1,009	70,044	..	..	..	..
	Australian Commonwealth.	"	14,331	8,19,644	..	..	..	..	..	..	..	..	..	..	6	350	..	..	..	..
	New Zealand	"	57,284	32,83,965	..	..	..	..	28,293	16,25,327	..	..	..		..	..	..	..	.	..
	Total British Empire	"	736,845	4,21,67,204	..	..	..	..	863,541	4,95,25,609	..	..	..	..	124,055	81,50,608	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6						7			
				1929-30.						1930-31.						1931-32.			
Mineral.	Kind of mineral.	Countries whence imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.	
				Quantity.	Value.	Quantity.	Value	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		FOREIGN COUNTRIES.			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Gold—*contd.*	Gold—*contd.* Bullion (bar, ingots and other kinds of uncoined gold)—*contd.*	France	Fine ounces.	9,048	5,53,147	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Maskat Territory and Trucial Oman.	"	40	2,320	..	..	..	..	4,625	2,61,833	..	..	..	..	17,871	11,55,629	..	..
		Other Native States in Arabia.	"	361	20,804	..	..	..	..	2,739	1,56,136	..	..	..	..	6,205	4,37,451	..	..
		Iraq	"	35,285	20,22,307	..	..	..	..	70,867	40,44,151	..	..	..	..	78,619	50,02,946	..	..
		China	"	2,626	1,46,065	..	..	..	..	106,088	62,04,325	..	..	..	..	175	27,580	..	..
		Egypt	"	319,072	1,82,48,677	..	..	..	..	21,424	12,29,215	..	..	..	..	..	..	..	..
		Total Foreign Countries.	"	367,032	2,09,93,820	..	..	..	..	205,743	1,18,94,660	..	..	..	..	103,170	66,23,611	..	..
		GRAND TOTAL .	"	1,103,877	6,31,00,524	..	..	..	..	1,009,284	6,14,20,209	..	..	..	..	227,225	1,47,74,214	..	..
Graphite . .	Graphite . .	United Kingdom .	Cwts.	2,991	77,716	..	..	..	..	3,518	80,004	..	..	..	..	2,035	51,353	..	..
		Ceylon	"	6,913	60,259	..	..	..	..	6,838	51,684	..	..	..	..	4,762	31,990	..	..
		Straits Settlements (including Labuan).	"	100	305	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire .	"	10,004	1,38,280	..	..	..	..	10,356	1,31,688	..	..	..	..	6,797	92,570	..	..
		FOREIGN COUNTRIES.																	
		Netherlands . .	"	31	483	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Germany . . .	"	110	479	..	..	..	..	137	1,262	..	..	..	..	200	4,066	..	..
		Italy	"	10	102	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Japan	"	50	423	..	..	..	..	51	345	..	..	..	..	51	426	..	..
		Java	"	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..
		United States of America *via* Atlantic Coast.	"	365	25,221	..	..	..	..	298	21,188	..	..	..	..	445	27,928	..	..
		Total Foreign Countries	"	566	26,708	..	..	..	..	486	22,795	..	..	..	..	705	32,425	..	..
		GRAND TOTAL .	"	10,570	1,64,988	..	..	..	..	10,842	1,54,483	..	..	..	..	7,502	1,15,004	..	..
Iron and Steel .	Iron—																		
	(a) Ore . .	United Kingdom .	Ton	1	105	..	..	..	..	..	148	..	..	..	..	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross Imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	FOREIGN COUNTRIES.			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Iron—*contd.* (*a*) Ore—*contd.*	Sweden	Tons.	23	2,937	..	..	..	..	50	6,197	..	..	..	..	27	3,319	..	..	..	..
	Belgium	"	..	..	..	..	..	..	..	..	..	..	..	..	5	501	..	..	..	..
	Total Foreign Countries.	"	23	2,937	..	..	..	..	50	6,197	..	..	..	..	32	3,820	..	..	..	..
	GRAND TOTAL	"	24	3,042	..	..	..	..	50	6,840	..	..	..	..	32	3,820	..	..	..	..
(*b*) Pig	United Kingdom	"	2,697	2,16,245	..	..	..	..	3,082	2,24,990	..	..	..	..	331	26,713	..	..	..	..
	FOREIGN COUNTRIES.																			
	Sweden	"	21	4,309	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Belgium	"	..	..	..	..	..	..	1	59	..	..	..	..	40	3,042	..	..	..	..
	Japan	"	1	60	..	..	..	..	..	45	..	..	..	..	..	..	..	..	..	..
	Italy	"	543	1,52,722	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Total Foreign Countries.	"	565	1,57,091	..	..	..	..	1	104	..	..	..	..	40	3,042	..	..	..	..
	GRAND TOTAL	"	3,262	3,73,336	..	..	..	..	3,083	2,25,103	..	..	..	..	380	30,355	..	..	..	..
Ferro-alloys	United Kingdom	"	..	..	..	..	..	..	185	40,222	..	..	..	..	[illegible]	16,454	..	..	..	..
	FOREIGN COUNTRIES.																			
	Sweden	"	..	..	..	..	..	..	10	2,476	..	..	..	..	..	..	..	..	..	..
	Norway	"	..	..	..	..	..	..	297	77,722	..	..	..	..	280	67,060	..	..	..	..
	Germany	"	..	..	..	..	..	..	103	22,608	..	..	..	..	65	12,297	..	.	..	
	Netherlands	"	..	..	..	..	..	..	..	..	..	..	..	..	105	31,350	..	..	..	..
	Belgium	"	..	..	..	..	..	..	5	1,675	..	..	..	..	..	..	..	..	..	..
	Switzerland	"	..	..	..	..	..	..	10	1,860	..	..	..	..	..	..	..	..	..	..
	Portugal	"	..	..	..	..	..	..	..	..	..	..	..	..	190	47,354	..	..	..	.
	Italy	"	..	..	..	..	..	..	549	1,43,780	..	..	..	..	40	10,163	..	..	..	..
	Greece	"	..	..	..	..	..	..	..	..	..	..	..	..	656	1,63,872	.	..	..	..
	Total Foreign Countries.	"	..	..	..	..	..	..	974	2,50,120	..	..	..	..	1,336	3,32,102	.	.	..	..
	GRAND TOTAL	"	..	..	..	..	..	..	1,159	2,90,342	..	..	..	..	1,422	3,48,556	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6					
				1929-30.						1930-31.					
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
		BRITISH EMPIRE.													
Lead . . .	Lead—unwrought—														
	(a) Ore . .	United Kingdom .	Ton.	9	4,259	..	..	..	..	15	5,604			.	
		Aden and Dependencies.	"	..	..	10	2,000	..	..	..	..	..	.		
		Bahrein Islands . .	"	..	..	..	40	..	..	..	..	..	..	..	..
		Ceylon . . .	"	..	..	..	..	..	..	..	..	..	..		
		Total British Empire .	"	9	4,259	10	2,010	..	..	15	5,604	..	.		..
		FOREIGN COUNTRIES.													
		Italian East Africa .	"	..	..	..	120	..	..	..	..	..		.	
		Belgium . . .	"	..	..	41	6,510	..	..	..	..	..			
		France . . .	"	218	88,072	..	..	..	..	237	88,432	..			
		Maskat Territory and Trucial Oman.	"	..	..	..	70	..	..	..	..		..	..	..
		Austria . . .	"	..	..	..	..	..	..	2	920	..	..	..	
		Other Native States in Arabia.	"	..	..	..	150	..	..	..	..	..	40	.	..
		United States of America *via* Atlantic Coast.	"	..	..	..	..	..	..	2	955	..	..	..	..
		Iraq	"	..	..	..	425	..	..	..	..	..	300	..	..
		Persia . . .	"	..	..	..	..	..	..	..	..	..	..	..	..
		Total Foreign Countries.	"	218	88,072	41	7,275	..	..	241	90,307	..	340	..	..
		GRAND TOTAL .	"	227	92,331	51	9,315	176	83,016	256	95,911	..	340	256	95,57

1931-32					
Gross imports		Exports		Retained imports	
Quantity	Value	Quantity	Value	Quantity	Value
	Rs		Rs		Rs
			[illegible]		
			[illegible]		
			[illegible]		
[illegible]	[illegible]				
			[illegible]		..
	..		[illegible]		
		1	300	..	
	..		385	..	
259	88,975	1	1,287		
259	88,975	1	1,417	258	87,558

1	2	3
Minerals and metals.	Kinds and grades.	Countries from which imported.
		BRITISH EMPIRE.
Lead—*contd.*	Lead—unwrought—*contd.* (*b*) Pig . .	United Kingdom .
		Bahrein Islands . .
		Ceylon . . .
		Kenya colony . .
		Mauritius and Dependencies.
		Total British Empire .
		FOREIGN COUNTRIES.
		Maskat Territory and Trucial Oman.
		France .
		Germany . .
		Italy . .
		Persia . . .
		Other Native States in Arabia.
		Total Foreign Countries.
		GRAND TOTAL .
		BRITISH EMPIRE.
	(*c*) Other sorts .	Aden and Dependencies.
		United Kingdom .
		Kenya Colony . .
		Ceylon . . .
		Bahrein Islands . .
		Tanganyika Territory .
		Total British Empire .

TABLE III.—*Imports of Minerals and Metals*—contd.

4	5						6						7					
	1929-30.						1930-31.						1931-32.					
Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Cwts.	941	17,325	..	..	..	..	929	14,311	..	..	..	..	3,089	36,127	..	..	..	..
,,	..	..	7	140	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	2,389	33,005	..	..	..	..	1,933	21,815	..	..	..	..	961	9,227	..	..	..	..
,,	..	..	..	..	..	..	13	238	..	..	..	..	..	..	..	..	..	..
,,	14	168	..	..	..	..	825	10,040	..	..	..	..	56	680	..	..	..	..
,,	3,204	50,498	7	140	..	..	3,700	46,404	..	..	..	..	4,106	46,034	..	..	..	..
,,	..	..	30	800	..	..	..	..	34	1,180	..	..	..	..	37	910	..	..
,,	432	5,500	..	.	..	..	99	1,973	..	..	..	.	.	..	..	..	..	..
,,	..	..	..	..	..	..	..	..	..	..	..	..	1	32	..	..	..	..
,,	..	..	..	..	..	..	2	36	..	..	..	..	..	..	..	..	..	..
,,	..	..	10	440	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	..	..	..	..	..	..	..	..	1	16	..	..	..	..	13	210	..	..
,,	432	5,500	49	1,300	..	..	101	2,009	35	1,202	..	..	1	32	50	1,120	..	..
,,	3,726	55,998	56	1,440	3,670	54,558	3,801	48,413	35	1,202	3,766	47,211	4,107	46,066	50	1,120	4,057	44,946
,,	..	..	..	..	..	..	..	..	50	1,500	..	..	..	..	..	..	..	.
,,	68	455	..	10	..	..	165	2,317	..	..	..	..	203	2,111	..	..	..	..
,,	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	238	1,554	2	40	..	..	85	570	2	100	..	..	211	1,595	285	5,620	..	..
,,	..	..	..	..	..	..	..	..	2	49	..	..	..	..	..	..	..	..
,,	..	..	5	'80	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	306	2,009	7	232	..	..	250	2,887	54	1,640	..	..	414	3,706	285	5,620	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6						7			
				1929-30.						1930-31.						1931-32.			
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
		FOREIGN COUNTRIES.																	
Lead—*contd.*	Lead—unwrought—*concld.* (c) Other sorts—*concld.*	Muscat territory and Trucial Oman.	Cwts.	..	..	195	5,500	..	..	..	..	107	2,505	..	..	..	..	110	3,215
		Belgium	"	..	..	..	..	..	..	..	..	..	..	..	..	..	..	[illegible]	[illegible]
		Iraq	"	65	805	..	..	..	..	86	751	[illegible]	500	..	..	[illegible]	[illegible]	..	..
		Persia	"	..	..	5	150	..	..	..	..	4	60	..	..	..	..	..	..
		Total Foreign Countries.	"	65	805	200	5,650	..	..	86	751	118	3,065	..	..	58	487	500	5,888
		GRAND TOTAL	"	371	2,814	207	5,882	..	..	336	3,038	172	4,714	..	..	172	1,193	815	11,508
Mica—	Mica—																		
	(a) In blocks	United Kingdom	"	59	11,463	..	..	..	..	410	64,572	..	..	..	..	121	17,405	..	..
		FOREIGN COUNTRIES.																	
		Germany	"	145	6,659	..	..	..	..	27	5,302	..	..	..	..	65	14,250	..	..
		Belgium	"	..	..	..	..	..	..	14	2,567	..	..	..	..	..	..	..	..
		France	"	188	14,455	..	..	..	..	1	640	..	..	..	..	..	..	..	..
		Italy	"	..	..	..	..	..	..	1	800	..	..	..	..	..	..	..	..
		Japan	"	10	1,572	..	..	..	..	10	3,028	..	..	..	..	36	10,552	..	..
		Madagascar	"	400	17,489	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		United States of America *vid* Atlantic Coast.	"	13	3,625	..	..	..	..	156	49,612	..	..	..	..	20	5,111	..	..
		Total Foreign Countries.	"	1,065	43,800	..	..	..	..	218	61,979	..	..	..	..	121	29,913	..	..
		GRAND TOTAL	"	1,124	55,263	..	..	..	..	628	1,26,551	..	..	..	..	245	47,318	..	..
		BRITISH EMPIRE.																	
	(b) In splittings	United Kingdom	"	5	1,633	..	..	..	..	166	11,191	..	..	..	..	114	9,985	..	..
		Ceylon	"	13	126	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire	"	18	1,759	..	..	..	..	166	11,191	..	..	..	..	114	[illegible]	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

3	4	5						6						7					
		1929-30.						1930-31.						1931-32.					
Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
FOREIGN COUNTRIES.																			
Germany . . .	Cwts.	94	8,114	..	..	..	..	82	12,256	..	..	..	..	108	6,321	..	..	..	..
Italy . . .	,,	..	..	..	..	..	..	..	..	..	..	..	..	3	2,412	..	..	..	..
Japan . . .	,,	40	1,540	..	..	..	..	9	3,570	..	..	..	..	..	..	..	..	..	..
United States of America *viâ* Atlantic Coast.	,,	19	6,218	..	..	..	..	..	..	..	..	..	..	..	65	..	..	..	..
Total Foreign Countries.	,,	153	15,872	..	..	..	..	91	15,826	..	..	..	..	111	8,708	..	..	..	..
GRAND TOTAL .	,,	171	17,031	..	..	..	..	257	27,020	..	..	..	..	255	18,786	..	..	..	..
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
BRITISH EMPIRE.																			
United Kingdom .	Cwts.	84	646	..	..	..	..	46	198	..	..	..	..	157	225	..	..	..	..
Straits Settlements (including Labuan)	,,	1,628,151	10,81,031	..	..	..	..	1,381,105	8,87,284	..	..	..	..	..	..	..	..	..	..
Total British Empire .	,,	1,628,235	10,81,677	..	..	..	..	1,381,151	8,87,482	..	..	..	..	157	225	..	..	..	..
FOREIGN COUNTRIES.																			
Celebes and other Islands.	,,	4,088	6,336	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Germany . . .	,,	32	187	..	..	..	..	321	903	..	..	..	..	..	..	..	..	..	..
Netherlands . .	,,	54	156	..	..	..	..	..	..	..	..	..	..	14	56	..	..	..	..
Persia . . .	,,	310,912	2,78,294	..	..	..	..	272,000	2,46,500	..	..	..	..	390,000	3,47,624	..	..	..	..
Sumatra . . .	,,	566,175	3,71,553	..	..	..	..	..	..	..	..	..	..	1,660,747	11,47,951	..	..	..	..
Siam . . .	,,	40	80	..	..	..	..	752	988	..	..	..	..	..	..	..	..	..	..
Iraq	,,	..	..	..	..	..	..	..	..	..	..	..	..	48	35	..	..	..	..
China . . .	,,	..	..	..	..	..	..	..	..	..	..	..	..	125	78	..	..	..	..
Java . . .	,,	12	12	..	..	..	..	..	..	..	..	..	..	17	21	..	..	..	..
United States of America— *Viâ* Atlantic Coast .	,,	743,944	4,88,213	..	..	..	..	1,614,755	15,08,042	..	..	..	..	8,822	9,632	..	..	..	..
,, Pacific ,, .	,,	1,401,127	16,20,053	..	..	..	..	5,564,382	46,16,350	..	..	..	..	9,882,381	79,37,602	..	..	..	..
Dutch New Guinea .	,,	..	..	..	..	..	..	..	..	..	..	..	..	790,265	10,87,223	..	..	..	..
Total Foreign Countries.	,,	3,026,384	27,64,884	..	..	..	..	7,452,210	63,72,787	..	..	..	..	12,741,419	1,04,80,222	..	..	..	..
GRAND TOTAL .	,,	4,654,619	38,46,561	..	..	..	..	8,836,361	72,60,269	..	..	..	..	12,741,576	1,04,80,447	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5 1929-30.						6 1930-31.						7 1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	BRITISH EMPIRE.																			
(b) Fuel oils.	United Kingdom	Gals.	..	..	..	..	..	..	132,234	24,573	..	..	..	..	191,395	34,770	..	..	..	..
	Ceylon	,,	3,150	1,954	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Straits Settlements (including Labuan).	,,	11,389,595	23,14,247	..	..	..	..	5,102,298	10,19,886	..	..	..	..	2,208,602	4,50,277	..	..	..	..
	British Borneo	,,	9,807,644	20,55,539	..	..	..	..	15,014,721	30,47,333	..	..	..	..	12,340,894	24,06,105	..	..	..	..
	Total British Empire	,,	21,200,389	43,71,740	..	..	..	..	20,219,253	40,91,792	..	..	..	..	14,740,981	20,51,242	..	..	..	..
	FOREIGN COUNTRIES.																			
	Iraq	,,	400	55	..	..	..	..	8,641	1,727	..	..	..	..	..	..	..	..	..	..
	Persia	,,	80,444,604	1,40,51,207	..	..	..	..	75,081,166	1,42,01,092	..	..	..	..	69,238,363	1,37,59,986	..	..	..	..
	Sumatra	,,	..	..	..	..	..	..	316,330	2,01,334	..	..	..	..	1,524,028	2,88,477	..	..	..	..
	Borneo (Dutch)	,,	8,454,601	16,33,294	..	..	..	..	9,180,318	22,40,659	..	..	..	..	11,021,674	25,54,362	..	..	..	..
	Japan	,,	102,044	18,450	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Roumania	,,	..	..	..	..	..	..	..	..	..	..	..	..	968,360	1,75,347	..	..	..	..
	Egypt	,,	..	..	..	..	..	..	152,083	51,519	..	..	..	..	67,801	22,748	..	..	..	..
	United States of America.	,,	1,060	306	..	..	..	..	718,115	2,44,410	..	..	..	..	2,330,204	6,20,392	..	..	..	..
	Other Countries	,,	..	..	..	..	..	..	4,057	938	..	..	..	..	28,518	6,851	..	..	..	..
	Total Foreign Countries.	,,	89,002,799	1,66,03,312	..	..	..	..	86,100,255	1,69,42,579	..	..	..	..	86,087,043	1,74,28,668	..	..	..	..
	GRAND TOTAL	,,	110,203,188	2,09,75,052	..	..	..	..	106,349,508	2,10,34,371	..	..	..	..	100,828,024	2,03,79,905	..	..	..	..
	BRITISH EMPIRE.																			
(c) Kerosene[1]	United Kingdom	,,	20	10	..	..	..	..	145	104	..	..	..	..	0	4	..	..	..	..
	Straits Settlements (including Labuan).	,,	11,266,902	58,22,257	..	..	..	..	435,929	2,10,735	..	..	..	..	15,154	9,089	..	..	..	..
	Other British Possessions.	,,	10	3	..	..	..	..	2	2	..	..	..	..	..	..	..	..	..	..
	Total British Empire	,,	11,266,932	58,22,270	..	..	..	..	436,076	2,19,841	..	..	..	..	15,163	9,093	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs
	FOREIGN COUNTRIES.																			
(c) Kerosene—contd.	Russia	Gals.	8,477,498	41,56,527	..	..	..	..	11,172,984	56,04,220	..	..	..	..	..	..	..	..	..	..
	Georgia	,,	20,736,624	1,06,99,260	..	..	..	..	22,049,237	1,21,85,621	..	..	..	..	24,020,825	1,12,85,874	..	..	..	..
	Persia	,,	29,392,401	1,57,07,072	..	..	..	..	18,213,874	85,65,800	..	..	..	..	18,551,926	95,46,076	..	..	..	..
	Azarbaijan	,,	7,631,176	44,07,649	..	..	..	..	13,702,204	64,65,095	..	..	..	..	17,440,144	71,84,542	..	..	..	..
	Borneo (Dutch)	,,	3,420,703	21,49,533	..	..	..	..	..	..	..	..	..	..	4,416,867	20,12,899	..	..	..	..
	Celebes and other Islands.	,,	2,155,530	11,00,221	..	..	..	..	11,938,746	60,98,780	..	..	..	..	..	..	..	..	..	..
	United States of America.	,,	23,375,044	1,17,40,405	..	..	..	..	21,290,108	1,13,14,205	..	..	..	..	20,362,017	1,27,51,587	..	..	..	..
	Roumania	,,	..	..	..	..	..	..	..	..	..	..	..	..	882,756	5,51,722	..	..	..	..
	Other Foreign Countries.	,,	425	500	..	..	..	..	16	17	..	..	..	..	222	150	..	..	..	..
	Total Foreign Countries.	,,	95,100,307	5,30,51,167	..	..	..	..	98,157,254	5,31,78,293	..	..	..	..	85,071,757	4,33,32,850	..	..	..	..
	GRAND TOTAL	,,	106,457,320	5,88,73,437	1,137	1,231	106,456,102	5,88,72,206	98,803,330	5,33,08,134	1,782	1,304	98,801,548	5,33,06,740	85,080,920	4,33,41,043	20,480	12,041	85,060,431	4,33,29,002
	BRITISH EMPIRE.																			
(d) Lubricating oils	United Kingdom	,,	1,326,241	25,02,104	..	..	..	..	1,135,733	19,00,071	..	..	..	..	1,514,518	26,70,959	..	..	..	..
	Ceylon	,,	13,416	14,684	..	..	..	..	2,476	3,247	..	..	..	..	7,904	13,541	..	..	..	..
	Straits Settlements (including Labuan).	,,	20,715	36,030	..	..	..	..	21,462	28,773	..	..	..	..	21,064	27,944	..	..	..	..
	Federated Malaya States.	,,	132	159	..	..	..	..	420	553	..	..	..	..	167	420	..	..	..	..
	British Borneo	,,	1,764	1,192	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Other British Possessions.	,,	..	..	..	..	..	..	..	..	..	..	..	..	770	770	..	..	..	..
	Total British Empire	,,	1,362,271	25,54,259	..	..	..	..	1,160,091	20,23,244	..	..	..	..	1,544,423	27,13,034	..	..	..	..
	FOREIGN COUNTRIES.																			
	Latvia	,,	2,477	2,330	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Germany	,,	54,784	45,569	..	..	..	..	195,107	1,50,712	..	..	..	..	38,195	57,233	..	..	..	..
	Netherlands	,,	54,031	53,144	..	..	..	..	135,720	1,17,277	..	..	..	..	83,046	75,764	..	..	..	..
	Belgium	,,	42,090	31,539	..	..	..	..	1,448	1,019	..	..	..	..	16,517	14,942	..	..	..	..

1	2	3
Minerals and metals.	Kinds and grades.	Countries from which imported.
		FOREIGN COUNTRIES —*contd.*
Petroleum—*concld.*	(*d*) Lubricating oils —*contd.*	France . . .
		Persia . . .
		Sumatra . . .
		Java . . .
		Borneo (Dutch) . .
		Celebes and other Islands.
		Japan . . .
		United States of America.
		Other Foreign Countries.
		Total Foreign Countries.
		GRAND TOTAL .
		BRITISH EMPIRE.
	(*e*) Paraffin wax .	United Kingdom .
		Straits Settlements (including Labuan).
		Victoria . . .
		Total British Empire .
		FOREIGN COUNTRIES.
		Poland (including Dantzig).
		Germany . . .
		Czechoslovakia . .
		Japan . . .
		United States of America.
		Other Foreign Countries.
		Total Foreign Countries.
		GRAND TOTAL .

TABLE III.—*Imports of Minerals and Metals*—contd.

4	5						6						7					
	1929-30						1930-31.						1931-32.					
Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Gals.	..	..	..	..	..	..	798	2,904	..	..	..	..	..	..	..	..	..	..
,,	508	2,048	..	..	..	..	11,430	25,634	..	..	..	..	1,100	2,861	..	..	..	..
,,	309,780	1,35,532	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	1,694	1,027	..	..	..	..	2,224	3,302	..	..	..	..	353	402	..	..	..	..
,,	10,505,294	59,19,681	..	..	..	..	1,927,438	27,70,227	..	..	..	..	3,727,880	21,00,205	..	..	..	..
,,	12	12	..	..	..	..	240,047	61,736	..	..	..	..	..	..	..	..	..	..
,,	192	584	..	..	..	..	35,580	70,126	..	..	..	..	601	1,048	..	..	..	..
,,	14,366,410	1,30,57,335	..	..	..	..	18,004,006	1,19,75,620	..	..	..	..	10,634,024	98,10,998	..	..	..	..
,,	160	745	..	..	..	..	141	231	..	..	..	..	714	1,691	..	..	..	..
,,	25,337,891	1,92,49,552	..	..	..	..	24,520,938	1,81,04,088	..	..	..	..	14,502,583	1,20,71,781	..	..	..	..
,,	26,609,002	2,18,03,811	..	..	..	..	25,681,020	2,02,17,932	..	..	..	..	16,047,006	1,47,85,418	..	..	..	..
Tons	28	15,800	..	..	..	..	73	40,164	..	..	..	..	2	2,421	..	..	..	..
,,	..	..	..	..	..	..	(a)	52	..	..	..	..	12	6,227	..	..	..	..
,,	..	..	..	..	..	..	10	6,985	..	..	..	..	..	..	..	..	..	..
,,	23	15,890	..	..	..	..	83	17,201	..	..	..	..	14	8,648	..	..	..	..
,,	44	14,942	..	..	..	..	7	2,140	..	..	..	..	..	..	..	..	..	..
,,	65	23,688	..	..	..	..	20	8,235	..	..	..	..	15	5,326	..	..	..	..
,,	20	8,885	..	..	..	..	20	5,127	..	..	..	..	..	..	..	..	..	..
,,	20	11,440	..	..	..	..	(a)	198	..	..	..	..	10	4,896	..	..	..	..
,,	985	2,93,189	..	..	..	..	1,562	3,12,654	..	..	..	..	482	1,04,302	..	..	..	..
,,	(a)	45	..	..	..	..	1	165	..	..	..	..	10	2,751	..	..	..	..
,,	1,134	3,52,189	..	..	..	..	1,600	3,28,519	..	..	..	..	517	1,17,365	..	..	..	..
,,	1,157	3,68,079	..	..	..	..	1,683	3,75,720	..	..	..	..	531	1,26,013	..	..	..	..

(a) Not available.

1	[illegible]					
Minerals and metals	Kinds [illegible]	[illegible]	[illegible]	[illegible]		
				[illegible]	[illegible]	Q[illegible]
Phosphates	Manures (excluding oil cakes)—Phosphatic—	BRITISH EMPIRE				
		United Kingdom	[illegible]			
		Ceylon				
	(a) Superphosphates	Total British Empire				
		FOREIGN COUNTRIES				
		Germany				
		Netherlands				
		Belgium				
		Japan				
		Total Foreign Countries				
		GRAND TOTAL				
		BRITISH EMPIRE				
	(b) Others	United Kingdom		1	1 19	
		Ceylon		[illegible]	[illegible]	..
		Seychelles				
		Other British Possessions			[illegible]	..
		Total British Empire		1 [illegible]	1 [illegible]	
		FOREIGN COUNTRIES				
		Germany		[illegible]	[illegible]	..
		Netherlands		[illegible] 110	[illegible] 00 901	
		Italy	,	[illegible]10	[illegible]	
		Belgium	,	7 [illegible]	7 01 [illegible]	
		United States of America	[illegible]	7 010	[illegible]	
		Egypt		174	[illegible],500	
		Other Countries	,	708	[illegible] 19,787	
		Total Foreign Countries		[illegible]8 871	[illegible],0[illegible]6	-
		GRAND TOTAL	,	80,867	[illegible],48 [illegible]56	

TABLE III. *Imports of Minerals and Metals*—contd.

[illegible]	[illegible]	[illegible]	6 1930-31. Gross Imports. Quantity.	Value.	Re-exports. Quantity.	Value.	Retained Imports. Quantity.	Value.	7 1931-32. Gross Imports. Quantity.	Value.	Re-exports. Quantity.	Value.	Retained Imports. Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs
	Not separately available								100	6,570	..	..	..	..
									89	13,225	..	..	..	..
									195	20,095	..	..	..	..
									180	9,884	.	..	..	.
	Not separately available								2,001	1,16,544	..	..	..	..
									1,314	99,851	..	..	..	..
									340	24,723	..	..	..	..
									3,788	2,51,002	..	..	..	..
									3,983	2,71,097	..	..	..	..
	.		[illegible]	[illegible]		.	.	.	10	[illegible]	..	..	..	..
			[illegible]	72		..	.	.	40	1,394	..	..	..	..
				.	..	.	..	..	400	8,710	..	..	..	..
				.	..	..	..	..	..	..	..	..	..	..
			[illegible]	[illegible]		..	..	..	100	12,488	.	..	..	..
			[illegible]	[illegible]	..	..	..	..	60	2,519	..	..	..	..
..	..		4,090	[illegible]		..	..	..	..	..	..	..	..	..
.			[illegible]	76,652	..	..	..	..	21	1,087	..	..	..	..
..	.		[illegible]	[illegible]	..	..	..		753	36,016	..	..	..	..
.	.	.	[illegible]	[illegible]	.	..	..	..	..	..	..	..	..	..
..		.	[illegible]	10,540	..	..	..	..	60	2,869	..	..	..	..
..	.		4,204	[illegible]	.	..	..	..	..	..	..	..	..	..
.	..	..	20,199	17,01,850	.	..	..	..	894	42,791	..	..	..	..
..	..	..	27,887	26,87,100	.	..	..	..	1,354	55,229	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6					
				1929-30.						1930-31.					
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Potash minerals	Chemicals and chemical preparations (excluding chemical manures and medicines) Potassium compounds—(a) Bichromate.	United Kingdom	Cwts.	2,453	75,051	..	..	..	..	1,735	52,303	..	..	..	..
		FOREIGN COUNTRIES.													
		Sweden	„	14	444	..	..	..	..	12	359	..	..	..	..
		Germany	„	2,269	66,661	..	..	..	..	2,297	68,813	..	..	..	..
		Switzerland	„	..	..	..	..	..	..	..	..	..	..	..	..
		Netherlands	„	1	72	..	..	..	..	25	812	..	..	..	..
		Belgium	„	49	1,454	..	..	..	..	..	..	..	..	..	..
		Japan	„	111	4,400	..	..	..	..	120	1,037	..	..	..	..
		United States of America *viâ* Atlantic Coast.	„	100	2,835	..	..	..	..	90	3,060	..	..	..	..
		Total Foreign Countries.	„	2,544	75,866	..	..	..	..	2,541	77,091	..	..	..	..
		GRAND TOTAL	„	4,997	1,50,917	..		..	..	4,276	1,29,394	..	..	..	..
	(b) Chlorate	United Kingdom	„	7	286	..	..	..	..	365	7,010	..	..	..	..
		FOREIGN COUNTRIES.													
		Finland	„	..	..	..	..	..	..	5,903	1,61,209	..	..	..	..
		Sweden	„	25,076	4,37,306	..	..	..	..	6,155	1,17,516	..	..	..	..
		Norway	„	853	14,868	..	..	..	..	..	..	..	..	..	..
		Germany	„	18,889	3,23,646	..	..	..	..	19,189	3,40,736	..	..	..	..
		Netherlands	„	..	..	..	..	..	..	1	32	..	..	..	..
		Belgium	„	426	7,916	..	..	..	..	424	8,230	..	..	..	..
		Switzerland	„	..	..	..	..	..	..	500	9,307	..	..	..	..
		France	„	1,714	30,560	..	..	..	..	1,150	21,480	..	..	..	..
		Czechoslovakia	„	100	1,736	..	..	..	..	..	..	..	..	..	..
		Japan	„	700	15,420	..	..	..	..	100	2,289	..	..	..	..
		China (exclusive of Hongkong and Macão)	„	..	..	..	..	..	..	..	..	..	..	..	..
		Total Foreign Countries.	„	47,758	8,31,452	..	..	..	..	36,722	6,00,805	..	..	..	..
		GRAND TOTAL	„	47,765	8,31,738	..	..	..	..	37,087	6,07,815	..	..	..	..

7

1931-32.

Gross imports.		Re-exports.		Retained imports.	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Rs.		Rs.		Rs.
3,130	1,11,057	..	..	..	..
..	..	..	..	..	..
2,962	1,09,790	..	..	..	..
20	615	..	..	..	..
..	..	..	..	..	..
..	..	..	..	..	..
82	2,607	..	..	..	..
410	15,410	..	..	..	..
3,474	1,28,422	..	..	..	..
6,604	2,39,479	..	..	..	..
1	64	..	..	..	..
5,388	1,21,718	..	..	..	..
12,455	2,94,800	..	..	..	..
..	..	..	..	..	..
12,502	2,69,543	..	..	..	..
..	..	..	..	..	..
1,142	24,804	..	..	..	..
..	..	..	..	..	..
3,120	69,042	..	..	..	..
99	1,780	..	..	..	..
250	4,747	..	..	..	..
100	1,878	..	..	..	..
35,056	7,86,297	..	..	..	..
35,057	7,86,851	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Chemicals and chemical preparations (excluding chemical manures and medicines) Potassium compounds—*contd.* (c) Cyanide of potassium.	United Kingdom	Cwts.	81	11,861	..	..	..	..	15	5,933	..	..	..	..	87	10,253	..	..	..	..
	FOREIGN COUNTRIES.																			
	Germany	,,	11	1,531	..	..	..	..	16	2,108	..	..	..	..	34	3,492	..	..	..	..
	Netherlands	,,	..	..	..	..	..	..	..	85	..	..	..	..	..	..	..	..	..	..
	Czechoslovakia	,,	250	12,070	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Total Foreign Countries.	,,	261	13,001	..	..	..	..	16	2,233	..	..	..	..	34	3,492	..	..	..	..
	GRAND TOTAL	,,	342	24,962	..	..	..	..	61	8,166	..	..	..	..	121	13,745	..	..	..	..
	BRITISH EMPIRE.																			
(d) Other sorts	United Kingdom	,,	1,130	1,06,907	..	..	..	..	602	1,41,222	..	..	..	..	558	1,24,247	..	..	..	..
	Ceylon	,,	..	..	..	..	..	..	..	8	..	..	..	..	..	..	..	..	..	..
	Total British Empire	,,	1,139	1,06,907	..	..	..	..	602	1,41,230	..	..	..	..	558	1,24,247	..	..	..	..
	FOREIGN COUNTRIES.																			
	Germany	,,	7,215	1,61,722	..	..	..	..	9,080	2,01,284	..	..	..	..	4,120	1,11,567	..	..	..	..
	Sweden	,,	250	4,250	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Netherlands	,,	730	22,015	..	..	..	..	402	21,022	..	..	..	..	29	11,121	..	..	..	..
	Belgium	,,	192	9,200	..	..	..	..	275	8,334	..	..	..	..	50	1,983	..	..	..	..
	France	,,	..	38	..	..	..	..	54	4,106	..	..	..	..	79	9,867	..	..	..	..
	Switzerland	,,	..	..	..	..	..	..	..	..	..	..	..	..	..	1,080	..	..	..	..
	Italy	,,	106	7,275	..	..	..	..	145	9,590	..	..	..	..	28	1,022	..	..	..	..
	Czechoslovakia	,,	40	1,276	..	..	..	..	270	8,035	..	..	..	..	..	..	..	..	..	..
	Japan	,,	103	1,44,632	..	..	..	..	73	75,301	..	..	..	..	82	83,300	..	..	..	..
	United States of America—																			
	Via Atlantic Coast	,,	103	9,248	..	..	..	..	3	1,157	..	..	..	..	1	76	..	..	..	..
	,, Pacific Coast	,,	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..
	Total Foreign Countries.	,,	8,835	3,63,565	..	..	..	..	10,308	3,30,428	..	..	..	..	4,398	2,20,717	..	..	..	..
	GRAND TOTAL	,,	9,974	4,70,472	..	..	..	..	10,970	4,71,658	..	..	..	..	4,956	3,44,964	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6						7			
				1929-30.						1930-31.						1931-32.			
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Potash minerals—*concld.*	Manures, Potassic—(a) Muriate of potash.	BRITISH EMPIRE.																	
		United Kingdom	Tons	..	..	..	..	..	..	202	23,705	..	..	..	..	..	16	..	..
		Ceylon	"	2	239	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire	"	2	239	..	..	..	..	202	23,705	..	..	..	..	..	16	..	..
		FOREIGN COUNTRIES.																	
		Germany	"	7,482	8,65,936	..	..	..	..	4,116	4,57,664	..	..	..	..	3,258	3,85,105	..	.
		France	"	..	..	..	..	..	..	..	..	..	..	..	..	185	23,138	..	..
		Belgium	"	2	266	..	..	..	..	..	..	..	..	..	..	1,175	1,82,330	..	..
		Egypt	"	..	..	..	..	..	..	..	..	..	..	..	..	120	12,100	.	..
		Total Foreign Countries.	"	7,484	8,66,202	..	..	..	..	4,116	4,57,664	..	..	..	..	5,017	6,03,173	..	..
		GRAND TOTAL	"	7,486	8,66,441	..	..	..	..	4,318	4,81,369	..	..	..	..	5,017	6,03,189	..	..
	(b) Others	United Kingdom	"	Not separately available.												..	6	..	..
		FOREIGN COUNTRIES.																	
		Germany	"													1,151	1,09,268	..	..
		Belgium	"													395	30,636	..	..
		Maskat territory and Trucial Oman.	"													1	100	..	..
		Total Foreign Countries.	"													1,547	1,40,004	..	..
		GRAND TOTAL	"													1,547	1,40,010	..	..
Quicksilver	Quicksilver.	BRITISH EMPIRE.																	
		United Kingdom	lbs.	43,371	1,82,890	..	..	..	..	43,883	1,93,734	..	..	..	..	48,011	1,90,553	..	..
		Straits Settlements (including Labuan).	"	110	440	..	..	..	..	1	6	..	..	..	..	..	..	..	..
		Bahrein Islands	"	..	..	80	320	..	..	..	..	..	..	..	..	..	..	75	300
		Hongkong	"	..	..	..	..	..	..	151	606	..	..	..	..	152	660	..	..
		Zanzibar and Pemba	"	..	..	75	350	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire.	"	43,481	1,83,330	155	670	..	..	44,035	1,94,346	..	..	..	..	48,163	1,91,213	75	300

TABLE III.—*Imports of Minerals and Metals*—contd.

3	4	5						6						7					
		1929-30.						1930-31.						1931-32.					
Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
		Quantity.	Value.	Quantity	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
FOREIGN COUNTRIES.																			
Germany	lbs.	7,329	30.927	..	..	..	..	5,371	23,495	..	..	..	..	193	971	..	..	..	..
Denmark	,,	..	..	..	..	..	..	..	..	..	..	..	..	2	16	..	..	..	..
Netherlands	,,	..	..	..	..	..	..	797	3,303	..	..	..	..	19	112	..	..	..	..
Russia, Southern	,,	..	..	76	250	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Belgium	,,	15,404	63,399	..	..	..	..	1,875	7,449	..	..	..	..	83	50	..	..	..	..
France	,,	1,875	7,200	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spain	,,	20,498	91,385	..	..	..	..	4,510	18,078	..	..	..	..	1,900	8,070	..	..	..	..
Other Native States in Arabia.	,,	..	..	228	885	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Italy	,,	105,701	4,40,155	..	..	..	..	121,503	5,11,120	..	..	..	..	160,683	6,53,107	..	..	..	..
Persia	,,	..	..	75	330	..	..	..	..	..	..	..	..	..	..	150	675	..	..
Austria	,,	1,900	8,500	..	..	..	..	3,600	14,400	..	..	..	..	6,030	24,120	..	..	..	..
Iraq	,,	..	..	1,051	4,407	..	..	..	..	75	330	..	..	..	..	.	..	..	..
China (exclusive of Hongkong and Macao).	,,	750	2,625	..	..	..	..	1,125	4,874	..	..	..	..	750	3,000	.	..	..	.
French Somaliland	,,	..	..	25	200	..	..	..	..	..	..	..	..	..	..	..	..	..	..
United States of America—																			
Viâ Atlantic Coast	,,	109	581	..	..	..	..	7,650	34,550	..	..	..	..	10	104	..	..	..	..
,, Pacific Coast	,,	..	..	..	..	..	..	..	..	..	..	..	..	300	1,500	..	..	..	..
Total Foreign Countries.	,,	153,656	6,44,772	1,455	6,072	..	..	146,521	6,18,178	75	330	..	..	169,920	6,91,056	150	675	..	..
GRAND TOTAL	,,	107,137	8,28,102	1,610	6,742	105,527	8,21,360	190,556	8,12,524	75	330	190,481	8,12,194	218,083	8,82,269	225	975	217,858	88,81,294

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6					
				1929-30.						1930-31.					
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value	Quantity.	Value.	Quantity.	Value.	Quantity.	Value
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
		BRITISH EMPIRE.													
Salt	Salt	United Kingdom	Tons	83,094	19,49,321	..	..	..	..	41,507	8,86,174	..	..	..	..
		Gibraltar	,,	..	..	..	..	..	..	2,236	40,123	..	..	..	..
		Aden and Dependencies.	,,	231,710	44,13,318	..	..	..	.	188,156	27,05,004	..	..	..	..
		Ceylon	,,	..	15	..	..	..	..	..	82	..	..	..	..
		Straits Settlements (including Labuan).	,,	15	1,334	..	..	..	..	11	1,051	..	..	..	..
		Federated Malay States.	,,	..	..	..	..	..	..	..	..	..	..	..	.
		Hongkong	,,	..	8	..	..	..	..	..	15	..	..	..	..
		Natal	,,	..	20	..	..	..	..	..	..	..	..	..	..
		Kenya Colony	,,	..	3	..	24	..	..	..	19	..	9	..	..
		Canada, Atlantic Coast.	,,	..	1	..	..	..	..	..	1	..	..	..	..
		South Australia	,,	..	2	..	..	..	..	..	1	..	..	..	..
		Victoria	,,	6	488	..	..	..	..	4	508	..	..	..	..
		New South Wales	,,	..	118	..	..	..	..	..	..	..	..	..	..
		Queensland	,,	..	..	..	..	..	..	..	20	..	..	..	..
		British West India Islands.	,,	1	84	..	..	..	..	..	..	..	..	..	..
		Mauritius and Dependencies.	,,	..	..	..	..	..	..	..	..	..	..	..	..
		Total British Empire	,,	314,826	63,64,707	..	24	..	..	232,307	37,32,988	..	9	..	..

1931-32.					
Gross import		Re-export		Retained imports	
Quantity	Value	Quantity.	Value	Quantity	Value
	Rs.		Rs.		Rs
25,553	5,66,419	.	.	..	..
..	..	..	..	..	..
313,631	48,75,676	..	7	..	..
.	1	..	..	..	..
3	216	.	..	..	..
..	1		..	..	..
..	..	.	..	..	..
..	18	..	..	..	..
..	8	..	..	..	..
..	..	..	..	..	..
..	..	..	..	..	..
1	271	..	..	..	..
..	2	..	..	..	..
..	2	..	..	..	..
..	..	..	..	..	..
..	8	..	..	..	.
339,191	54,12,495	..	7	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Salt—*contd.*	FOREIGN COUNTRIES.																			
	Germany	Tons	62,904	14,20,629	..	..	..	..	97,014	20,24,893	..	..	..	..	25,000	4,81,707	..	..	..	..
	Netherlands	"	..	214	..	..	..	..	..	239	..	..	..	..	..	124	..	..	..	..
	France	"	..	..	..	..	..	..	..	25	..	..	..	..	..	..	..	..	..	..
	Spain	"	69,368	14,13,543	..	..	..	..	66,916	10,45,005	..	..	..	..	3,781	67,380	..	..	..	..
	Italy	"	..	7	..	..	..	..	..	3	..	..	..	..	..	..	..	..	..	..
	Roumania	"	7,876	1,50,091	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Other Native States in Arabia.	"	..	20	..	4	..	..	..	29	..	..	..	..	..	..	..	..	..	..
	Maskat Territory and Trucial Oman.	"	..	5	..	..	..	..	..	3	..	..	..	..	..	..	..	..	..	..
	Java	"	..	59	..	..	..	..	2,035	44,327	..	..	..	..	..	22	..	..	..	..
	Siam	"	5	306	..	..	..	..	2	313	..	..	..	..	1	73	..	..	..	..
	Japan	"	..	28	..	9	..	..	2	58	..	..	..	..	..	27	..	..	..	..
	Indo-China	"	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
	Iraq	"	..	3	..	10	..	..	..	23	..	..	..	..	..	8	..	..	..	..
	Persia	"	..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	..	..
	China (*exclusive* of Hongkong and Macao).	"	1	433	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..
	Egypt	"	104,879	20,64,875	..	..	..	..	134,531	21,03,051	..	..	..	..	15,305	2,28,000	..	..	..	..
	Portuguese East Africa	"	..	..	..	5	..	..	2,177	48,165	..	..	..	..	..	..	..	..	..	..
	Italian East Africa (Somaliland and Eritrea).	"	68,465	13,17,386	..	..	..	..	154,130	22,17,500	..	..	..	..	67,196	9,78,362	..	..	..	..
	French Somaliland	"	15,522	2,05,612	..	..	..	..	13,600	1,80,248	..	..	..	..	..	..	..	..	..	..
	United States of America—																			
	Viâ Atlantic Coast	"	..	355	..	..	..	..	..	186	..	..	..	..	1	222	..	..	..	..
	" Pacific "	"	..	1,230	..	..	..	..	..	632	..	..	..	..	..	345	..	..	..	..
	Total Foreign Countries	"	329,020	66,73,022	..	28	..	..	471 336	77,04,106	..	..	..	..	111,893	17,56,374	..	..	..	..
	GRAND TOTAL	"	643,846	1,30,38,629	..	52	643,846	1,30,38,577	703,643	1,14,97,094	..	9	703,643	1,14,97,085	451,084	71,98,869	..	7	451,084	71,98,862

TABLE III.—*Imports of Minerals and Metals*—contd.

1	2	3	4	5						6			
				1929-30.						1930-31.			
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross Imports.		Re-exports.		Retained Imports.		Gross Imports.		Re-exports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.
		BRITISH EMPIRE.											
Silver . . .	Silver Bullion (bar and other kinds of uncoined silver).	United Kingdom .	Standard ounces.	55,906,374	7,38,16,635	..	..	..	..	64,896,319	7,58,82,727	..	..
		Bahrein Islands . .	,,	17,904	23,709	..	..	..	..	21,497	25,370	..	..
		Ceylon . . .	,,	32,404	41,133	..	..	..	..	2,060	2,391	..	..
		Maldives . . .	,,	..	..	..	..	..	..	..	..	..	..
		Straits Settlements (*including* Labuan).	,,	49	75	..	..	..	..	618,971	6,63,898	..	..
		Hongkong . . .	,,	..	..	..	..	..	..	874,140	9,53,153	..	..
		Natal . . .	,,	572,418	7,02,155	..	..	..	..	1,091,825	12,67,520	..	..
		Zanzibar and Pemba .	,,	3,878	5,424	..	..	..	..	..	..	..	..
		Kenya Colony . .	,,	..	..	..	..	..	..	..	..	..	..
		Tanganyika Territory .	,,	..	..	..	..	..	..	..	..	..	..
		Australian Commonwealth.	,,	10,808,710	1,57,00,203	..	..	..	..	9,069,082	1,10,39,156	..	..
		New Zealand . .	,,	148,462	2,31,726	..	..	..	..	..	..	..	..
		Total British Empire .	,,	67,490,208	9,06,11,060	..	..	..	..	76,603,808	8,98,43,224	..	..
		FOREIGN COUNTRIES.											
		France . . .	,,	805,896	9,90,274	..	..	..	..	860,794	11,22,577	..	..
		Italy . . .	,,	381,755	5,12,290	..	..	..	..	..	..	..	..
		Maskat Territory and Trucial Oman.	,,	640	838	..	..	..	..	1,329	1,533	..	..
		Other Native States in Arabia.	,,	22,982	30,838	..	..	..	..	19,629	23,591	..	..
		Iraq	,,	..	..	..	..	..	..	20	37	..	..
		Persia . . .	,,	105,442	1,36,060	..	..	..	..	..	..	..	..
		China (*exclusive* of Hongkong and Macao).	,,	865,096	10,64,233	..	..	..	..	6,490,538	68,94,275	..	..
		Egypt . . .	,,	5,851,106	79,56,052	..	..	..	..	..	..	..	..
		United States of America.	,,	17,631,134	2,33,56,252	..	..	..	..	22,140,060	2,33,17,068	..	..
		Total Foreign Countries.	,,	25,664,060	3,40,55,837	..	..	..	..	29,521,870	3,13,50,981	..	..
		GRAND TOTAL .	,,	93,154,268	12,46,66,897	..	..	..	..	106,125,678	12,11,94,205	..	..

		7					
		1931-32.					
Retained imports.		Gross imports.		Re-exports.		Retained imports	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value	Quantity.	Value
	Rs.		Rs.		Rs.		Rs.
..	..	19,691,774	2,38,25,398	..	..	..	..
..	..	19,181	25,017	..	..	..	..
..	..	4,320	6,318	..	..	..	..
..	..	92	40	..	..	..	..
..	..	64	116	..	..	..	..
..	..	..	..	..	..	..	..
..	..	417,197	4,70,443	..	..	..	..
..	..	307	619	..	..	..	..
..	..	9	9	..	..	..	..
..	..	22	81	..	..	..	..
..	..	4,487,649	55,66,088	..	..	..	..
..	..	183,278	2,31,810	..	..	..	..
..	..	24,803,893	3,01,37,898	..	..	..	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..
..	..	8,433	11,079	..	..	..	..
..	..	11,742	13,902	..	..	..	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..
..	..	618,959	8,61,173	..	..	..	..
..	..	..	..	..	..	..	..
..	..	3,761,876	48,86,966	..	..	..	..
..	..	4,401,010	57,73,180	..	..	..	..
..	..	29,204,903	3,59,11,078	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

3	4	5						6						7					
		1929-30.						1930-31.						1931-32.					
Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
			Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
BRITISH EMPIRE.																			
United Kingdom .	Cwts.	7,949	40,122	..	..	..	..	3,427	21,300	..	..	..	..	51,772	2,25,344	..	..	..	..
Straits Settlements (*including* Labuan).	,,	1	10	..	..	..	..	..	..	..	..	..	..	5	98	..	..	..	..
Ceylon . . .	,,	..	..	..	..	..	..	238	1,387	..	..	..	..	20	210	..	..	..	..
Victoria . . .	,,	268	2,067	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tanganyika Territory .	,,	..	..	..	..	..	..	..	..	..	..	..	..	140	2,800	..	..	..	..
Total British Empire .	,,	8,218	52,099	..	..	..	..	3,665	22,687	..	..	..	..	51,937	2,28,452	..	..	..	..
FOREIGN COUNTRIES.																			
Sweden . . .	,,	..	..	..	..	..	..	200	1,160	..	..	..	..	..	..	..	..	..	..
Germany . . .	,,	23,367	1,27,888	..	..	..	..	54,243	2,54,393	..	..	..	..	21,412	1,11,601	..	..	..	..
Netherlands . .	,,	31	808	..	..	..	..	800	4,511	..	..	..	..	20	228	..	..	..	..
Austria . . .	,,	..	..	..	..	..	..	..	..	..	..	..	..	1,160	5,909	..	..	..	..
Belgium . . .	,,	660	4,235	..	..	..	..	244	1,808	..	..	..	..	..	..	..	..	..	..
France . . .	,,	20	175	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..
Persia . . .	,,	4	35	..	..	..	..	..	..	..	..	..	..	8	40	..	..	..	..
Italy . . .	,,	338,079	16,66,339	..	..	..	..	283,265	14,70,524	..	..	..	..	232,715	12,16,777	..	..	..	..
China (*exclusive* of Hongkong and Macao).	,,	1	150	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Japan . . .	,,	1,941	30,596	..	..	..	..	1,732	24,488	..	..	..	..	1,527	29,276	..	..	..	..
Java . . .	,,	..	..	..	..	..	..	..	..	..	..	..	..	12	208	..	..	..	..
United States of America *viâ* Atlantic Coast.	,,	36,730	1,58,615	..	..	..	..	9,245	54,728	..	..	..	..	2,882	17,262	..	..	..	..
Total Foreign Countries	,,	400,842	19,88,841	..	..	..	..	349,729	18,11,604	..	..	..	..	259,736	13,81,296	..	..	..	.
GRAND TOTAL .	,,	409,060	20,40,940	..	..	..	..	353,394	18,34,291	..	..	..	..	311,673	16,09,748	..	..	..	..

1 Minerals and metals.	2 Kinds and grades.	3 Countries from which imported.
		BRITISH EMPIRE.
in	Tin—Unwrought (blocks, ingots, bars and slabs).	Palestine . . .
		United Kingdom .
		Aden and Dependencies.
		Bahrein Islands . .
		Ceylon . . .
		Zanzibar and Pemba .
		Kenya Colony . .
		Straits Settlements (*including* Labuan).
		Seychelles . . .
		Federated Malay States.
		Tanganyika Territory .
		Total British Empire .
		FOREIGN COUNTRIES.
		Belgium . . .
		France . . .
		China (*exclusive* of Hongkong and Macao).
		Japan . . .
		Russia—
		Southern Russia .
		Northern Russia .
		Maskat Territory and Trucial Oman.
		Other Native States in Arabia.
		Persia . . .
		Iraq . . . .

TABLE III.—*Imports of Minerals and Metals*—contd.

4	5 1929-30.						6 1930-31.						7 1931-32.					
Unit	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Cwts.	..	..	5	163	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	1,557	2,26,000	..	..	..	..	1,081	1,10,870	.	..	..	..	727	[illegible]	..	..	..	..
"	..	..	..	125	..	..	..	..	9	961	..	..	..	..	..	..	..	..
"	..	..	18	2,600	..	..	..	..	16	2,350	..	..	..	..	11	800	..	..
"	8	315	17	1,372	..	..	11	1,287	6	720	..	.	[illegible]	[illegible]	23	501	..	..
"	..	..	1	175	..	..	..	..	1	370	..	.	..	..	1	100	..	..
"	..	..	1	270	..	..	..	..	5	501	..	..	..	..	..	..	..	..
"	55,310	77,13,768	..	..	..	.	53,058	52,81,317	..	..	..	..	11,168	[illegible]	..	..	..	..
"	..	..	..	60	..	..	..	..	2	295	..	..	..	..	..	..	..	..
"	..	..	..	..	..	..	6	105	..	..	..	..	..	..	..	..	..	.
"	..	..	1	670	..	..	..	..	2	960	..	..	..	..	..	..	..	..
"	56,870	[illegible]	16	5,435	..	..	51,161	53,93,969	11	[illegible]	..		[illegible]	[illegible]	[illegible]	1,101	..	..
"	..	..	..	..	..	..	4	606	..	..	..	..	..		..	..	..	..
"	..	..	..	..	..	..	8	873	..	..	..	..	..	..	..	.	..	..
"	180	69,254	..	..	..	..	201	18,880	..	..	..	..	..	..	..	..	..	..
"	100	12,182	..	..	..	..	81	3,375	..	..	..	..	..	..	..	..	..	..
"	..	..	15	2,125	..	..	..	..	18	1,900	.	..	..	..	..	..	..	..
"	.	..	10	1,600	..	..	..	..	..	..	..	..	..	..	..	..	..	..
"	..	..	12	1,521	..	..	..	..	11	1,270	..	..	..	..	1	110	..	..
"	..	..	101	13,610	..	..	..	..	103	11,300	..	..	..	..	10	770	..	..
"	..	..	328	47,802	..	..	..	..	828	89,065	..	..	..	..	231	24,211	..	..
"	..	..	176	25,865	..	..	..	..	293	26,290	..	..	..	..	184	21,450	..	..

TABLE III.—*Imports of Minerals and Metals*—contd.

2	3	4	5						6						7					
			1929-30.						1930-31.						1931-32.					
Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.	
			Quantity.	Value.	Quantity	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
				Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
	FOREIGN COUNTRIES —*contd.*																			
Tin—Unwrought (blocks, ingots, bars and slabs) —*contd.*	Portuguese East Africa.	Cwts.	..	..	1	125	..	..	..	..	..	..	..	..	..	..	1	90	..	..
	French Somaliland .	"	..	..	1	200	..	..	..	..	..	..	..	..	..	..	4	350	..	..
	Italian East Africa .	"	..	..	2	300	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Siam	"	..	..	..	..	..	..	..	..	1	90	..	..	..	..	..	..	..	..
	Total Foreign Countries	"	589	81,496	646	93,208	..	..	247	23,733	1,254	1,40,003	..	..	..	..	431	47,004	..	..
	GRAND TOTAL .	"	57,408	80,27,419	602	98,043	56,776	79,28,776	54,408	54,17,702	1,208	1,45,398	53,110	52,72,304	45,251	41,27,212	466	48,408	44,785	40,78,804
	BRITISH EMPIRE.																			
Zinc or spelter (unwrought).	United Kingdom .	"	51,626	9,28,336	..	..	..	..	34,431	3,00,930	..	..	..	..	58,791	5,72,777	..	..	..	..
	Aden and Dependencies.	"	67	1,080	..	..	..	..	45	605	..	..	..	..	3	12	..	..	..	..
	Ceylon . . .	"	266	4,144	..	..	..	..	77	1,074	..	..	..	..	3,272	30,652	..	..	..	..
	Straits Settlements (*including* Labuan).	"	1	12	..	..	..	..	3	30	..	..	..	..	..	..	..	..	..	..
	Zanzibar and Pemba .	"	31	675	..	..	..	..	53	642	..	..	..	..	26	426	..	..	..	..
	Kenya Colony . .	"	40	550	..	..	..	..	20	555	..	..	..	..	39	500	..	..	..	..
	Tanganyika Territory .	"	80	1,710	..	..	..	..	87	750	..	..	..	..	18	180	..	..	..	..
	Mauritius and Dependencies.	"	4	78	..	..	..	..	235	3,811	..	..	..	..	..	..	..	..	..	..
	Canada—																			
	Viâ Pacific Coast .	"	450	7,469	..	..	..	..	..	..	..	..	..	..	2,601	27,543	..	..	..	..
	" Atlantic " .	"	..	..	..	..	..	..	..	..	..	..	..	..	800	9,845	..	..	..	..
	Victoria . . .	"	..	..	..	..	..	..	15,466	2,00,397	..	..	..	..	19,967	2,13,988	..	..	..	..
	Tasmania . . .	"	..	..	..	..	..	..	2,000	26,958	..	..	..	..	8,401	74,094	..	..	..	..
	New South Wales .	"	..	..	..	..	..	..	7,405	92,812	..	..	..	..	10,498	1,13,078	..	..	..	..
	South Australia . .	"	..	..	..	..	..	..	..	..	..	..	..	..	2,000	21,942	..	..	..	..
	Total British Empire .	"	52,574	9,44,660	..	..	..	..	59,781	7,27,504	..	..	..	..	106 406	10,73,987	..	..	..	..

TABLE III.—*Imports of Minerals and Metals*—concld.

1	2	3	4	5						6							
				1929-30.						1930-31.							
Minerals and metals.	Kinds and grades.	Countries from which imported.	Unit.	Gross imports.		Re-exports.		Retained imports.		Gross imports.		Re-exports.		Retained imports.		Gross imports.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.		Rs.		Rs.		Rs.		Rs.
Zinc—*contd.*	Zinc or spelter (unwrought)—*contd.*	FOREIGN COUNTRIES.															
		Poland	Cwts.	500	8,944	..	..	..	..	1,700	25,313	..	..	..	..	3,830	41,471
		Germany	"	72,861	14,52,746	..	..	..	..	15,837	2,21,521	..	..	..	..	17,158	1,99,421
		Netherlands	"	399	7,195	..	..	..	..	326	4,058	..	..	..	..	350	3,553
		Belgium	"	740	15,720	..	..	..	..	1,731	25,875	..	..	..	..	1,314	18,409
		Italy	"	..	..	..	..	..	..	..	..	..	..	..	..	500	4,568
		France	"	..	..	..	..	..	..	20	285	..	..	..	..	..	..
		Maskat Territory and Trucial Oman.	"	4	65	..	..	..	..	..	..	..	..	..	..	..	..
		Japan	"	200	3,216	..	..	..	..	1,000	12,704	..	..	..	..	6,658	69,088
		Iraq	"	44	710	..	..	..	..	..	..	..	..	..	..	..	..
		Portuguese East Africa	"	3,181	53,614	..	..	..	..	7,208	1,03,251	..	..	..	..	9	65
		United States of America—															
		Viâ Atlantic Coast	"	6,079	90,201	..	..	..	..	40	1,240	..	..	..	..	20,352	2,21,225
		" Pacific "	"	6,100	98,143	..	..	..	..	82,155	12,11,382	..	..	..	..	23,401	2,31,372
		Total Foreign Countries	"	90,108	17,30,563	..	..	..	..	110,017	16,08,129	..	..	..	..	73,572	7,89,265
		GRAND TOTAL	"	142,682	26,84,223	..	..	..	..	169,798	23,35,698	..	..	..	..	179,978	18,63,252

7

1931-32.

Re-exports.		Retained imports.	
Quantity.	Value	Quantity.	Value.
	Rs.		Rs.
..	..	..	..
..	..	..	..
..	..	..	..
..	..	..	.
..	..	..	..
..	..	..	..
..	..	..	..
..	..	..	..
..	..	..	..
..	..	..	..
.	..	..	..
.	..	..	..
	..	..	..
	..	..	..

1	2			7					
				1931-32.					
Minerals and metals.	Kinds and gr	Retained imports		Gross imports		Re-exports		Retained imports	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
			Rs		Rs		Rs		Rs.
Zinc—*contd.*	Zinc or s (unwrou —*contd.*	..	.	3,830	11,474	..	..	..	..
		..	..	17,158	1,09,421	.	..	..	..
		..	..	350	3,553	..	..	..	.
		..	..	1,814	18,409	..	..	..	.
		..	..	500	4,568	..	..	..	..
		..	..	..	..	..	..	..	..
		..	..	.	..	..	..	..	.
		..	..	6,658	60,088	..	..	..	..
		..	..	..	..	..	..	.	.
		..	..	9	65	..	..	.	.
		..	.	20,352	2,21,225	..	..	..	..
		..	.	23,401	2,31 372	..	..	..	..
		..	..	73,572	7 80,265	..	..	..	..
		..	..	170,978	18,63,252	..	..	..	..

TABLE IV.—*Exports of Minerals and Metals.*

—				1929.		1930.		1931.	1932.
Exchange value of Rupee in terms of Pound Sterling.			£1=	Rs. 18·4		Rs. 18·5		Rs. 13 5	Rs. ..
1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
Antimony	Antimonial lead Pb=77 per cent., Sb=21 per cent., 6·8 oz. Ag to the ton.	United States of America.	Tons.	1,200[1]	3,37,101[1]	1,700[2]	3,54,994[2]	..	..
Chrome-ore and chromium.	Chromite (Chrome iron-ore).	United Kingdom	„	1,600	50,510	2,454	88,625	3,799	1,26,472
		FOREIGN COUNTRIES.							
		Norway	„	..	..	4,260	1,27,770	..	..
		Germany	„	7,100	2,13,000	3,500	1,05,000	3,600	1,16,000
		Netherlands	„	..	..	..	..	150	6,000
		Belgium	„	180	6,346	267	9,850	200	6,500
		France	„	150	5,500	1,400	43,000	395	14,850
		Italy	„	750	22,500	1,560	46,800	100	3,000
		United States of America— *Viâ* Atlantic coast	„	75,000	2,80,500	6,750	2,35,255	..	..
		„ Pacific coast	„	..	..	450	18,000	..	..
		Total Foreign Countries.	„	15,680	5,27,846	18,187	5,85,675	4,445	1,46,350
		GRAND TOTAL	„	17,280	5,78,356	20,641	6,74,300	8,244	2,72,822

[1] Figures for 1929.
[2] Figures for 1930.

TABLE IV.—*Exports of Minerals and Metals*—contd.

1 Minerals and metals.	2 Kinds and grades.	3 Ultimate countries to which exported.	4 Unit.	5 1929-30. Domestic production. Quantity.	5 1929-30. Domestic production. Value.	6 1930-31. Domestic production. Quantity.	6 1930-31. Domestic production. Value.	7 1931-32. Domestic production. Quantity.	7 1931-32. Domestic production. Value.
					Rs.		Rs.		Rs.
		BRITISH EMPIRE.							
Coal, coke and By-Products.	Coal and coke—								
	(a) Coal . .	United Kingdom .	Tons.	19,550	2,17,828	8,057	75,120	11,955	1,05,882
		Aden and Dependencies.	"	7,437	81,807	..	..	..	..
		Bahrein Islands .	"	1	45	..	..	25	450
		Ceylon . . .	"	340,730	41.08,240	295,767	30.15,499	272,080	32,91,260
		Straits Settlements (including Labuan).	"	59,013	6,83,640	25,158	2,68,914	22,773	2,40,432
		Federated Malay States.	"	..	..	5,074	62,241	97	1,018
		Hongkong . .	"	172,658	12,81,112	55,944	5,38,528	162,265	14,18,684
		Mauritius and Dependencies.	"	2,181	23,441	2,007	22,077	1,180	12,980
		New South Wales .	"	3,060	33,600	..	..	..	..
		Fiji Islands . .	"	..	..	2,488	26,124	..	..
		Natal . . .	"	..	..	..	..	620	5,580
		Total British Empire	"	604,580	64,29,782	394,495	16.03,503	471,600	50,71,286
		FOREIGN COUNTRIES.							
		Germany . .	Tons.	..	..	57	1,750	1	20
		Iraq . . .	"	80	2,190	201	4,327	35	952

	[illegible]ca . . .	,,	80	2,060	..	..	1,133	14,088
	Sumatra . .	,,	6,066	63,693	..	..	..	..
	Java . . .	,,	2,400	25,200	432	6,130	..	..
	Philippine Islands and Guam.	,,	57,868	5,00,556	32,985	2,84,310	37,007	3,17,709
	China (exclusive of Hongkong and Macao).	,,	8,348	92,242	..	..	..	..
	Japan . . .	,,	5,822	45,230	..	..	5,341	47,920
	Belgium . .		9	60	..	..	..	..
	Other Native States in Arabia.	,,	6	240	..	..	..	..
	Total Foreign Countries.	,,	80,679	7,31,471	33,675	2,96,567	43,517	3,80,699
	GRAND TOTAL .	,,	685,239	71,61,253	428,170	49,05,070	515,117	54,51,985
	BRITISH EMPIRE.							
(b) Coke . .	Ceylon . . .	Tons.	636	10,877	649	10,831	480	9,998
	Straits Settlements (including Labuan).	,,	1,606	27,993	737	14,842	627	13,030
	Aden and Dependencies.	,,	2	94	1	40	..	..
	Kenya Colony .	,,	3	150	..	..	1	33
	Hongkong . .	,,	..	..	..	..	5	200
	Mauritius and Dependencies.	,,	20	605	..	..	..	..
	United Kingdom .	,,	..	..	21	400	..	..
	Cape of Good Hope	,,	..	..	..	..	1	20
	Federated Malay States.	,,	..	..	..	..	709	13,815
	Total British Empire	,,	2,267	39,719	1,428	25,618	1,829	37,096

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
Coal, coke and By Products—*contd.*	Coal, and coke—*contd.* (*b*) Coke—*contd.*	FOREIGN COUNTRIES.							
		Iraq . . .	Tons.	105	4,539	92	4,025	37	1,770
		Persia . . .	"	..	..	..	..	4	100
		Total Foreign Countries.	"	105	4,539	92	4,025	41	1,870
		GRAND TOTAL .	"	2,372	44.258	1,520	29,638	1,870	38,966
		BRITISH EMPIRE.							
Copper . .	(*a*) Wrought, sheets and other manufactures.	United Kingdom .	Cwts.	22	2,410	12	1,526	1	340
		Aden and Dependencies.	"	55	5,147	33	3,375	35	3,500
		Bahrein Islands .	"	11	1,070	..	..	..	..
		Maldives. . .	"	17	1,058	18	1,320	31	1,450
		Ceylon . . .	"	781	63,582	564	51,349	465	38,247
		Straits Settlements (including Labuan).	"	945	78.140	373	30,372	218	17,120
		Federated Malay States.	"	15	1,560	2	150	20	2,025
		Hongkong . .	"	2	140	1	100	2	125
		Natal . . .	"	25	3,305	25	2,380	8	760

	Zanzibar and Pemba	"	38	3,920	21	2,075	33	2,707
	Kenya Colony .	"	93	9,085	46	5,875	28	2,765
	Tanganyika Territory.	"	21	2,490	7	535	8	1,100
	Mauritius and Dependencies.	"	1	180	24	2,070	2	105
	Other British Possessions.	"	18	1,386	7	625	1	80
	Total British Empire	"	2,044	1,73,413	1,188	1,01,752	872	70,824
	FOREIGN COUNTRIES.							
	Netherlands . .	"	48	2,140	..	..	..	..
	Maskat Territory and Trucial Oman.	"	8	630	2	120	4	295
	Other Native States in Arabia.	"	127	095	76	5,826	34	2,655
	Iraq . . .	"	46	6,178	38	3,730	87	12,525
	Persia . . .		18	1,080	9	600	2	100
	Portuguese East Africa.	"	5	505	12	775	10	1,020
	Madagascar . .	"	8	550	..	..	..	..
	French Somaliland .	"	27	2,840	14	1,425	..	..
	Other Foreign Countries.	"	11	1,100	13	1,300	12	611
	Total Foreign Countries.	"	293	27,118	164	18,776	149	17,206
	GRAND TOTAL .	"	2,337	2,00,531	1,297	1,15,528	1,021	87,530
	BRITISH EMPIRE.							
(b) Others . .	United Kingdom .	Cwts.	97	500	764	8,800	6,855	42,565
	Other British Possessions.	"	5	295	..	..	..	..
	Total British Empire	"	102	795	764	8,800	6,855	42,565

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
Copper—*contd.*	(*b*) Others—*contd.*	FOREIGN COUNTRIES.							
		Germany	Cwts.	245,719	49,14,578	344,122	60,99,268	241,982	26,73,898
		Netherlands	,,	20,350	4,07,000	..	..	..	..
		Total Foreign Countries.	,,	266,069	53,21,578	344,122	60,99,268	241,982	26,73,898
		GRAND TOTAL	,,	266,171	53,22,173	344,326	61,08,068	248,537	27,16,463
	(*c*) Copper matte	Germany (Hamburg)	Tons	11,303[1]	50,20,544[1]	17,146[2]	45,97,974[2]	13,487[3]	32,25,003[3]
		BRITISH EMPIRE.							
Gold[4]	Bullion (bar, ingots and other kinds of uncoined gold).	United Kingdom	Fine ounces.	..	..	86,354	48,97,992	6,181.140	47,19,51,028
		Straits Settlements	,,	..	..	489	29,000	..	..
		Total British Empire	,,	..	..	86,843	49,26,992	6,181.140	47,19,51,028
		FOREIGN COUNTRIES.							
		Netherlands	,,	..	..	..	..	492.827	3,39,67,512
		Belgium { Private	,,	..	..	..	..	571	24,503
		Belgium { Government.	,,	62	2,551	..	..	..	..
		France	,,	..	..	..	..	92,866	[illegible]

		Maskat Territory and Trucial Oman.	,,	..	..	38	2,172	..	..
		Japan . . .	,,	..	..	..	..	1,877	1,23,219
		United States of America.	,,	..	..	..	..	989,749	7,16,99,515
		Total Foreign Countries—Private . .	,,	..	..	38	2,172	1,577,190	11,23,98,604
		Government .	,,	62	3,551	..	..	..	..
		GRAND TOTAL—							
		PRIVATE . .	,,	..	..	86,881	49,29,164	7,758,330	58,48,79,632
		GOVERNMENT .	,,	62	3,551	..	..	..	..
Iron and steel	Iron or steel—								
	(a) Ore . .	Japan . . .	Tons	101	3,030	802	12,520	437	3,431
		GRAND TOTAL .	,,	101	3,030	802	12,520	437	3,431
		BRITISH EMPIRE.							
	(b) Pig . .	United Kingdom .	,,	71,277	33,20,747	98,950	38,48,148	69,088	24,10,609
		Ceylon . . .	,,	184	8,278	114	4,428	107	3,747
		Straits Settlements (including Labuan).	,,	1,261	56,764	925	85,527	294	10,276
		Federated Malay States.	,,	533	28,961	172	6,218	111	3,871
		Hongkong . .	,,	1,309	58,881	2,134	80,122	2,268	79,384
		Natal . . .	,,	603	28,167	500	22,020	152	5,350
		Canada *viâ* Pacific Coast.	,,	..	..	..	..	150	5,250
		Total British Empire	,,	75,167	34,96,793	102,795	39,96,458	72,170	25,18,487

[1] Figures for 1929, Cu=39·84 per cent Pb=29·70 per cent. 63·27 ozs. Ag to the ton.
[2] Figures for 1930, Cu=41·9 per cent. Pb=28·01 per cent. 69·25 ozs. Ag to the ton.
[3] Figures for 1931, Cu=43·54 per cent. Pb=27·77 per cent. and 84·97 ozs. Ag to the ton.
[4] In the figure of gold exports domestic production and exports of gold imported in previous years cannot be distinguished. The exports for 1931-32 consist, of course, mainly of the latter.

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Iron or steel—	FOREIGN COUNTRIES.			Rs.		Rs.		Rs.
Iron & steel—*contd.*	(*b*) Pig—*contd.*	Norway	Tons	468	21,849	363	13,379	90	3,153
		Denmark	,,	..	..	..	..	26	898
		Sweden	,,	3,280	1,50,884	4,881	1,89,083	1,363	48,550
		Germany	,,	14,723	6,72,956	11,032	4,27,716	13,022	4,54,842
		Netherlands	,,	136	6,847	664	22,805	2,506	98,150
		Belgium	,,	4,354	1,96,281	13,626	4,37,544	3,302	1,15,535
		France	,,	..	..	1,099	24,189	..	..
		Italy	,,	11,779	5,55,100	8,194	3,32,561	3,010	1,04,518
		Bulgaria	,,	..	..	101	4,566	..	..
		Roumania	,,	..	..	101	4,546	..	..
		Java	,,	11	488	29	1,041	62	2,171
		Iraq	,,	5	375	15	1,125	..	..
		Siam	,,	..	..	503	17,614	..	..
		China	,,	11,753	5,49,071	17,527	6,88,727	12,742	4,51,245
		Japan	,,	349,512	1,53,68,071	160,584	64,11,426	138,106	65,75,921
		Egypt	,,	449	20,202	331	32,829	621	21,76[illegible]
		Portuguese East Africa.	,,	52	2,340	50	1,750	..	..

		United States of America—							
		Vid Atlantic coast	,,	68,819	30,97,740	99,469	37,30,426	44,520	15,60,108
		,, Pacific coast	,,	17,240	7,76,648	8,702	3,54,246	6,450	2,25,627
		Mexico	,,	505	22,946	..	..	..	..
		Uruguay	,,	29	3,960	39	1,758	..	..
		Argentine Republic	,,	8,899	4,06,731	7,125	2,90,554	910	31,874
		Chile	,,	1,560	70,267	1,154	44,968	846	12,116
		Colombia	,,	..	..	17	595	..	..
		Peru	,,	62	2,798	22	763	20	700
		Hawaii	,,	515	23,141	202	9,098	253	8,870
		Indo-China	,,	..	..	10	463	1,010	35,340
		Total Foreign Countries	,,	493,646	2,24,43,195	330,840	1,30,43,772	278,688	97,51,387
		GRAND TOTAL	,,	568,813	2,59,39,988	489,135	1,70,40,230	350,858	1,22,69,874
Ferro-alloys	Ferro-manganese	....	,,	3,200	19,200	Figures not available.			
		BRITISH EMPIRE.							
Lead	Metal—								
	Lead—Pig	United Kingdom	Cwts.	920,778	1,54,48,608	1,144,745	1,65,70,490	847,660	1,13,32,085
		Ceylon	,,	65,908	11,08,922	57,153	8,91,116	48,996	5,87,849
		Straits Settlements (including Labuan)	,,	3,840	64,756	4,898	74,107	2,920	38,629
		Hongkong	,,	6,697	1,09,859	13,083	1,87,336	22,793	2,98,830
		Federated Malay States	,,	60	990	..	..	80	1,064
		Total British Empire	,,	997,283	1,67,33,180	1,219,879	1,77,23,049	917,449	1,22,58,457

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
		FOREIGN COUNTRIES.							
Lead—*contd.*	Lead—Pig—*contd.*	Germany	Cwts.	201,004	33,97,610	59,002	8,16,930	17,000	2,12,643
		Netherlands	„	20,003	3,40,031	..	..	..	..
		Belgium	„	122,000	20,57,953	27,999	4,26,990	2,003	20,531
		Italy	„	..	..	49,002	6,78,424	66,001	8,79,124
		Persia	„	66	792	..	..	..	..
		Java	„	299	5,287	519	9,572	138	2,586
		Sumatra	„	..	..	..	..	134	1,745
		Siam	„	..	..	200	2,998	..	..
		China (exclusive of Hongkong and Macao).	„	10,927	1,79,250	10,994	1,56,912	6,069	82,059
		Japan	„	104,256	17,33,233	130,965	18,73,740	285,853	35,62,866
		Muskat Territory and Trucial Oman.	„	5	125	..	..	..	..
		Total Foreign Countries.	„	458,560	77,19,216	278,679	39,65,366	377,181	50,09,996
		GRAND TOTAL	„	1,455,643	2,44,52,596	1,498,558	2,16,83,615	1,294,820	1,72,23,447
Magnesite	Magnesite	United Kingdom	„	14,350	79,257	10,755	61,380	6,768	48,925

		FOREIGN COUNTRIES.							
		Belgium . .	,,	2,000	95,000	..	..	8,320	52,350
		Germany . .	,,	14,000	66.500	18,000	63,400	4,000	19,000
		Netherlands . .	,,	51,992	2,46,960	56,000	2,66,000	36,201	1.70,775
		United States of America.	,,	68,100	3.18,525	48,200	2,27,200	12,800	60,000
		Other countries .	,,	731	14.406	846	18.635	2,526	26,722
		Total Foreign Countries.	,,	136,823	7,41,391	123,046	5,80,235	63,847	3,28,847
		GRAND TOTAL .	,,	151,173	8.20,648	133,801	6,41,615	70,615	3,76,572
		BRITISH EMPIRE.							
Manganese . .	(*a*) Manganese-ore	United Kingdom .	Tons	292,377	86,64.816	114,010	34,22,883	53,843	16,06,032
		Gibraltar . .	,,	1,000	30.000	2,000	48.000	..	..
		Canada— *Via* Atlantic coast	,,	..	..	3,260	88,020	..	..
		,, Pacific coast .	,,	..	..	..	..	100	3,000
		New South Wales .	,,	4,100	1,12,750	..	..	..	..
		Total British Empire	,,	297,477	88,07,566	119,270	35,58,903	53,943	16.09,032
		FOREIGN COUNTRIES.							
		Russia— Northern Russia .	,,	1,888	60,654	..	..	..	..
		Norway . . .	,,	2,800	56,300	5,000	1,75,000	3,500	93,000
		Sweden . . .	,,	300	8,200	2,500	75,000	..	..
		Germany . .	,,	22,550	7,03,020	15,330	4,61,209	1,820	40,504
		Netherlands . .	,,	34,850	9,78,112	11,500	4.00,000	2,500	89,375
		Belgium . .	,,	177,584	48.23,671	78,495	23,97,918	35,400	10,65,100
		France . . .	,,	208,238	53,52,735	188.409	49,46,106	80,325	17,87,140

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.*	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Manganese—*contd.*	(*a*) Manganese-ore —*contd.*	FOREIGN COUNTRIES. —*contd.*			Rs.		Rs.		Rs.
		Italy	Tons	4,246	1,49,920	620	15,600	..	..
		Hungary	"	..	..	8,500	2,55,000	..	..
		Czechoslovakia	"	..	..	1,500	45,000	..	..
		Indo-China	"	..	..	..	..	..	25
		Japan	"	15,290	3,70,365	5,799	1,39,018	6,120	1,23,567
		United States of America *via* Atlantic coast.	"	51,500	15,45,000	48,850	14,41,100	28,120	3,44,200
		Total Foreign Countries.	"	518,196	1,40,48,867	366,503	1,08,50,951	157,794	40,42,911
		GRAND TOTAL	"	815,678	2,23,56,453	485,773	1,39,09,854	211,737	56,51,943
	(*b*) Ferruginous manganese-ore.	United Kingdom	"	..	..	..	..	..	300
		FOREIGN COUNTRIES.							
		Belgium	"	5,600	33,600	3,000	19,500	1,200	7,200
		France	"	19,210	1,15,260	2,000	16,000	2,000	16,000
		Total Foreign Countries.	"	24,810	1,48,860	5,000	35,500	3,200	23,200
		GRAND TOTAL	"	24,810	1,48,860	5,000	35,500	3,200	23,500

Mica . . .	Mica—	BRITISH EMPIRE.							
	(a) In blocks .	United Kingdom .	Cwts.	8,967	21,38,195	8,247	15,05,472	5,186	9,23,168
		Canada *via* Atlantic coast.	"	21	4,853	36	9,601	8	3,087
		Western Australia .	"	1	900	..	..	..	..
		Victoria . . .	"	5	3,350	21	10,566	1	300
		New South Wales .	"	1	750	9	6,810	..	..
		New Zealand (including Nauru and British Samoa).	"	1	700	2	1,950	1	154
		Total British Empire	"	8,996	21,48,748	8,315	15,34,399	5,199	9,26,704
		FOREIGN COUNTRIES.							
		Sweden . . .	"	..	..	14	2,183	..	..
		Germany . .	"	915	1,51,550	515	79,739	91	20,483
		Netherlands . .	"	..	..	65	14,732	..	..
		Belgium . .	"	116	6,723	1	390	7	2,095
		France . . .	"	1,396	3,03,532	707	1,59,664	184	49,426
		Italy . . .	"	542	86,162	277	44,994	201	73,181
		China (exclusive of Hongkong and Macao).	"	2	3,000	1	1,100	..	..
		Japan . . .	"	576	1,85,889	720	1,64,958	895	1,37,784
		United States of America *via* Atlantic coast.	"	6,384	14,30,682	1,642	3,91,924	1,111	1,40,612
		Equador . .	"	..	..	7	1,422	..	..
		Other Native States in Arabia.	"	1	700	..	..	..	..
		Total Foreign Countries.	"	9,932	21,18,238	3,949	8,61,111	2,489	4,23,481
		GRAND TOTAL .	"	18,928	42,66,986	12,264	23,95,510	7,688	13,50,185

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Mica—*contd.*	Mica—*contd.*	BRITISH EMPIRE.			Rs.		Rs.		Rs.
	(*b*) In splittings—	United Kingdom .	Cwts.	33,170	21,21,247	26,026	19,57,586	19,073	12,82,033
		Canada *via* Atlantic coast.	,,	913	2,25,155	434	87,088	709	1,10,457
		Victoria . . .	,,	2	300	5	550	5	400
		New South Wales .	,,	1,400	2,450	820	1,435	400	700
		Ceylon . . .	,,	1	25	..	..	..	..
		Total British Empire	,,	35,486	23,49,177	27,285	20,46,659	20,187	13,43,590
		FOREIGN COUNTRIES.							
		Sweden . . .	,,	..	..	42	4,362	40	1,125
		Germany . .	,,	10,864	4,95,689	5,103	3,03,393	6,866	1,72,806
		Netherlands . .	,,	465	18,060	324	17,866	341	12,644
		Belgium . .	,,	2,225	96,497	1,214	88,665	1,031	80,401
		France . . .	,,	7,183	1,26,169	4,988	1,24,978	2,463	23,553
		Italy . . .	,,	649	69,144	1,133	1,44,443	2,593	2,54,706
		Austria . . .	,,	..	..	140	15,630	..	..
		Japan . . .	,,	2,598	1,45,607	2,440	61,967	3,158	67,939

		United States of America *via* Atlantic coast.	,,	36,242	27,40,481	19,135	15,54,888	12,001	6,29,374
		Total Foreign Countries.	,,	60,226	36,91,597	34,519	23,16,742	25,493	12,42,048
		GRAND TOTAL .	,,	95.712	60,40,774	61,804	43,63,401	45,650	25,85,638
Nickel . . .	Nickel-speiss .	Germany (Hamburg)	Tons	3,065[1]	6,38,780[1]	3,150[2]	7,26,168[2]	2,911[3]	6,73,973[3]
Nitrates (*see* under Potash Mineral)—	Oils—Minerals—								
Petroleum and allied natural products (including shale oil).	Dangerous Petroleum flashing below 76°F including petrol, benzine and benzol.	United Kingdom .	Gals.	498	350	..	..	256	289
		Persia . . .	,,	..	..	92	115	..	..
		United States of America *via* Atlantic coast.	,,	..	..	..	..	46	60
		Total Foreign Countries.	,,	..	..	92	115	46	60
		GRAND TOTAL .	,,	488	350	92	115	302	349
Potash minerals .	Saltpetre . .	....	Cwts.	85,172	8,87,265	88,341	7,52,345	133,938	10,57,916
		BRITISH EMPIRE.							
Salt . . .	Salt . . .	Ceylon . . .	Tons	1	240	3	429	1	301
		United Kingdom .	,,	..	..	..	[illegible]	..	..
		Hongkong . .	,,	6	500	6	1,030	3	350
		Straits Settlements (including Labuan).	,,	4	629	5	1,000	3	573
		Maldives . .	,,	..	..	..	..	..	3
		Kenya Colony .	,,	..	8	..	61	..	..
		Mauritius and Dependencies.	,,	..	..	..	..	..	31

[1] Figures for 1929, Ni=27·08 per cent., Cu=13·16 per cent., Co=3-4 per cent. and also 30·03 oz. Ag per ton.
[2] Figures for 1930, Ni=30·19 per cent., Cu=10·48 per cent., Co=3-4 per cent. and also 28·38 oz. Ag to the ton.
[3] Figures for 1931, Ni=27·68 per cent., Cu=10·75 per cent., and 32·32 ozs. of Ag to the ton.

TABLE IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	1929-30. Domestic production.		1930-31. Domestic production.		1931-32. Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
		BRITISH EMPIRE—*contd.*							
Salt—*contd.*	Salt—*contd.*	British West India Islands.	Tons	..	103	..	343	..	234
		British Guiana	"	..	93	..	112	..	48
		Fiji Islands	"	1	907	..	90	..	472
		Federated Malay States.	"	..	..	..	..	..	11
		Total British Empire	"	12	2,480	14	3,128	7	2,023
		FOREIGN COUNTRIES.							
		Germany	"	..	..	..	..	..	2
		Maskat Territory and Trucial Oman.	"	..	62	..	..	..	13
		Siam	"	1	50	..	..	..	..
		Dutch Guiana	"	..	26	..	39	1	15
		Iraq	"	..	..	..	10	..	16
		Portuguese East Africa.	"	..	..	..	38	..	48
		Total Foreign Countries.	"	1	138	..	87	1	94
		GRAND TOTAL	"	13	2,618	14	3,215	8	2,117

Silver[1]—	Bullion (bar and other kinds of uncoined silver).	BRITISH EMPIRE.								
		United Kingdom—								
		Private	Standard ounces.	..	..	1,119	2,000	2,599,363	36,57,507
		Government	,,	25,519,789	3,32,33,717	13,743,537	1,39,62,663	30,042,309	3,01,88,761
		Ceylon	,,	15,388	22,823	50	122	..	..
		Hongkong	,,	..	..	13,133,824	1,47,75,844	9,131,541	99,37,297
		Fiji Islands	,,	1,149	1,535	..	..	..	..
		Total British Empire							
		Private	,,	16,537	23,858	13,134,993	1,47,77,966	11,730,904	1,35,94,804
		Government	,,	25,519,789	3,32,33,717	13,743,537	1,39,62,663	30,042,309	3,01,88,761
		FOREIGN COUNTRIES.							
		Belgium—							
		Government	,,	6,178	8,582	..	..	..	..
		Muskat Territory and Trucial Oman.	,,	7,784	10,020	7,979	8,941	1,032	1,740
		Other Native States in Arabia.	,,	113,013	1,51,346	..	..	..	..
		Iraq	,,	98,811	1,37,000	..	..	..	..
		Egypt	,,	..	..	208	240	..	..
		Total Foreign Countries—							
		Private	,,	219,608	2,98,366	8,187	9,181	1,032	1,740
		Government	,,	6,178	8,582	..	..	..	..
		GRAND TOTALS—							
		Private	,,	236,145	3,22,224	13,143,180	1,47,87,147	11,731,936	1,35,96,544
		Government	,,	25,525,967	3,32,42,299	13,743,537	1,39,62,663	30,042,309	3,01,88,761

[1] As with gold these exports are partly of domestic production, but are mainly re-exports of the imports of previous years.

Table IV.—*Exports of Minerals and Metals*—contd.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
Tin	Tin—	British Empire.							
	(a) Ore	United Kingdom	Tons	1,123	26,74,216	659	11,97,818	121	1,18,382
		Straits Settlements (including Labuan).	"	2,208	37,64,240	1,865	21,78,479	2,241	23,14,183
		Total British Empire	"	3,331	64,38,456	2,524	33,76,297	2,362	24,32,565
		Germany	"	..	9	..	..	..	..
		Grand Total	"	3,331	64,38,465	2,524	33,76,297	2,362	24,32,565
	(b) Un-wrought (blocks, ingots, bars and slabs).	United Kingdom	Cwts.	4,293	1,35,317	1,913	59,933	43,584	1,34,062
		Aden and Dependencies.	"	..	..	2	100	..	..
		Straits Settlements (including Labuan).	"	2	150	..	..	..	..
		Total British Empire	"	4,295	1,35,467	1,915	60,033	43,584	1,34,062

		FOREIGN COUNTRIES.							
		Netherlands . .	,,	-2,600	6,370	2,720	6,682	..	..
		Belgium . .	,,	1,700	3,505	7,572	8,787	8,353	12,248
		Italy . . .	,,	1,681	9,400	3,960	4,667	..	..
		France . . .	,,	400	480	..	..	..	..
		Germany . .	,,	100	143	..	..	..	..
		Japan . . .	,,	10	15	..	..	..	..
		Total Foreign Countries.	,,	6,491	19,913	14,252	20,136	8,353	12,248
		GRAND TOTAL .	,,	10.786	1,55,380	16,167	30,169	51,987	1,46,310
Tungsten . .	Wolframite mostly	United Kingdom .	Tons	1,247	10,61,166	3,204	52,46,991	3,410	56,43,510
		FOREIGN COUNTRIES.							
		Germany . .	,,	333	5,17,364	413	3,84,452	672	3,92,585
		Belgium . .	,,	125	1,78,000	122	1,00,895	277	1,81,062
		France . .	,,	83	99,200	62	63,200	25	17,710
		Italy . . .	,,	..	..	10	6,000	..	..
		United States of America *viâ* Atlantic Coast.	,,	30	43,000	..	..	..	..
		Total Foreign Countries.	,,	621	8,37,564	607	5,54,547	974	5,91,357
		GRAND TOTAL .	,,	1,868	27,98,730'	3,811	58,01,538	4,384	62,34,867

TABLE IV.—*Exports of Minerals and Metals*—concld.

1	2	3	4	5		6		7	
				1929-30.		1930-31.		1931-32.	
Minerals and metals.	Kinds and grades.	Ultimate countries to which exported.	Unit.	Domestic production.		Domestic production.		Domestic production.	
				Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Rs.		Rs.		Rs.
		BRITISH EMPIRE.							
Zinc . . .	Zinc or spelter, all sorts.	United Kingdom	Cwts.	1,244	7,960	1	50	..	..
		Straits Settlements (including Labuan).	,,	4	40	..	..	..	..
		Ceylon . . .	,,	10	125	..	..	..	..
		Total British Empire	,,	1,258	8,125	1	50	..	..
		FOREIGN COUNTRIES.							
		Germany . .	,,	64,000	3,20,000	30,000	75,000	50	1,000
		Belgium . .	,,	1,250,950	62,54,750	1,195,000	54,25,000	1,126,300	28,15,250
		Total Foreign Countries.	,,	1,314,950	65,74,750	1,225,000	55,00,000	1,126,350	25,16,250
		GRAND TOTAL .	,,	1,316,208	65,82,875	1,225,001	55,00,050	1,126,350	23,16,250

ERRATA.

Owing to revised figures having been received after the printing of Table V, the following corrections should be made in that Table :—

Arsenic—*For* 2,107 *read* 2,114 in columns 4 and 6.

Borax—*For* 18,742 *read* 18,242 in columns 4 and 6.

Petroleum—Petrol including benzene and dangerous spirit—*For* 13,547,678 *read* 13,547,642 in column 4; and *for* 36,101,460 *read* 36,101,424 in column 6.

Potash, chemicals and manures—*For* 142,721 *read* 152,721 in columns 4 and 6.

Salt—*For* 532,753 *read* 528,594 in column 4; and *for* 2,086,109 *read* 2,081,950 in column 6.

TABLE V.—*Consumption, 1931.*

Ores and minerals.	Kinds and grades.	Unit.	Production.	Retained imports.	Exports of domestic production.	Minerals, ores and metals available for consumption. Columns 3+4—5.	Estimate of local annual consumption.	Surplus; only sufficient; or *insufficient.*
1	2	2*a*	3	4	5	6	7	8
Aluminium	Aluminium unwrought (ingots, block, etc.).	Cwts.	..	44	..	44	Whole	Insufficient.
Aluminium-ore	Bauxite	Tons	*Nil.* (*a*)	..	..	..	..	..
Antimony	Antimonial lead	,,	1,505	..	(*b*)	..	..	Surplus.
Arsenic	Metal and oxides	Cwts.	(*c*)	2,107	..	2,107	Whole	Insufficient.
Asbestos	Chrysotile and other kinds	Tons	6	..	(*d*)	6	..	Insufficient.
Barytes	....	,,	5,654	4,530	..	10,184	Whole	Insufficient.
Bismuth-ore	Mostly native	Lbs.	42	..	..	..	..	..
Borates	Borax (including boracic acid).	Cwts.	*Nil.* (*e*)	18,742	..	18,742	Whole	Insufficient.
Brass	....	Tons	3,637	(*f*)	(*f*)	3,637	Whole	Insufficient.
China clay	....	,,	23,365	20,708	..	44,073	Whole	Insufficient.
Chrome-ore	Chromite	,,	19,913	..	13,243(*g*)	6,670	Small quantity	Surplus.

(*a*) 2,514 tons in 1930.
(*b*) Known to be exported but export figures are not available.
(*c*) Considerable: figures not available at present.
(*d*) Production propably exported.
(*e*) Last production was 7 cwts. in 1929.
(*f*) Large annual imports. Average annual value for 1924 to 1928 was Rs. 2,65.54 811. These are in part balanced by exports of annual value of Rs. 18,36,517 for the same period. Imports of brass, bronze and similar alloys and manufactures in 1930-31 were 19,009 tons.
(*g*) Includes 5,585 tons of chromite produced in British India, exported from Mormugao port in Portuguese India.

TABLE V.—*Consumption, 1931*—contd.

Ores and minerals.	Kinds and grades.	Unit.	Production.	Retained imports.	Exports of domestic production.	Minerals, ores and metals available for consumption. Columns 3+4—5.	Estimate of local annual consumption.	Surplus; only sufficient; or *insufficient.*
1	2	2a	3	4	5	6	7	8
Coal, coke and by-products.	Bituminous non-coking coal, bituminous coking coal, anthracite.	Tons	21,716,485	88,085	441,249	21,363,221	?	Surplus.
	Coal tar and pitch	Cwts.	953,940	56,933	..	1,010,873	Whole	Insufficient.
	Sulphate of ammonia	Tons	12,133	14,996	3,001	24,128	Almost whole	Insufficient.
Copper	Metal (unwrought)	,,	4,060	289	..	*Nil.*	4,069(*a*)	Insufficient.
Copper-matte	....	,,	13,487	..	14,156(*b*)	*Nil.*	*Nil.*	Surplus.
Diamonds	....	Carats	639	(*c*)	..	639	..	Insufficient.
Ferro-manganese	....	Tons	14,366	..	..	14,366	..	Sufficient.
Ferro-alloys (*d*)	....	,,	..	1,502	..	1,502	..	Insufficient.
Fuller's earth	....	,,	2,958	..	..	2,958	..	Sufficient.
Gold	....	Ounces	330,489	249,632	4,903,888(*e*)	..	..	Surplus.
Graphite	....	Tons	6	502	..	508	Whole	Insufficient.
Gypsum	....	,,	53,632	..	..	53,632	Whole	Sufficient.
Iron	Ore	,,	1,624,888					
	Pig	,,	1,058,836	1,288	318,994	740,625	..	Surplus.
	Steel	,,	439,134					
Lead	Pig	,,	73,2[illegible]0	229	68,515	4,994	..	Surplus.

Magnesite	....	,,	5,233	..	(*f*)	..	Small amount	Surplus.
Manganese-ore	....	,,	537,844	..	417,957(*g*)	119,887	Small amount	Surplus.
Mica	....	Cwts.	38,963	667	52,966	..	Small amount	Surplus.
Monazite	....	Tons	89·6	..	(*h*)	..	Small	Surplus.
Nickel-speiss	....	,,	2,911	..	(*i*)	..	Small	Surplus.
Petroleum	Crude	Gallons	305,018,751	..	..	305,018,751	Whole	Insufficient.
	Petrol including benzene and dangerous spirit.	,,	22,558,982	13,547,678	150	36,101,460	Whole	Insufficient.
	Heavy benzene	,,	41,268,500	..	..	41,268,500	Whole	Sufficient.
	Kerosene	,,	147,550,020	72,997,029	..	220,547,049	Whole	Insufficient.
	Fuel oil	,,	14,593,991	104,313,690	..	118,907,681	Whole	Insufficient.
	Lubricating oils	,,	9,192,810	19,252,211	..	28,445,021	Whole	Insufficient.
	Paraffin wax	Tons	49,397(*j*)	847	51,602	..	Small	Surplus.
Phosphates	....	,,	109	8,054	..	8,163	Whole	Insufficient.
Potash minerals and chemicals including saltpetre.	Saltpetre	Cwts.	136,717(*k*)	..	123,117	13,600	Small	Surplus.
	Potash chemicals and manures.	,,	..	142,721	..	142,721	Whole	Insufficient.
Quicksilver	....	Lbs.	*Nil.*	185,517	..	185,517	..	Insufficient.
Salt	....	Tons	1,553,363	532,753	7	2,086,109	Whole	Insufficient.

(*a*) Mainly converted into 'yellow metal' (brass).
(*b*) It is presumed that this figure for 'copper-wrought-others' refers to copper-matte, the whole of which is exported for smelting abroad.
(*c*) Quantity not known. Value of the precious stones imported in 1931 amounted to Rs. 4,095,921.
(*d*) May include ferro-manganese.
(*e*) Total exports.
(*f*) Magnesite is known to be exported but the export figures are not available.
(*g*) Includes 171,410 tons produced in India but exported from Mormugao, a port in Portuguese India."
(*h*) Monazite is known to be exported but export figures are not available.
(*i*) Nickel-speiss is known to be exported but export figures are not available. They must approximate to the amount produced.
(*j*) Converted from gallons at the ratio of 249 gallons = 1 ton.
(*k*) Figures of production no longer available. The figure 136,717 cwts. is the sum of the exports 123,117 cwts. *plus* 13,600 cwts. consumed on tea gardens.

TABLE V.—*Consumption, 1931*—concld.

Ores and minerals.	Kinds and grades.	Unit.	Production.	Retained imports.	Exports of domestic production.	Minerals, ores and metals available for consumption. Columns 3 + 4—5.	Estimate of local annual consumption.	only surplus; sufficient; or *insufficient.*
1	2	2a	3	4	5	6	7	8
Silver	....	Fine ounces	5,923,005	70,466,988	35,124,714(a)	41,265,279	Considerable .	Insufficient.
Sulphur . . .	....	Cwts.	*Nil.*	314,565	..	314,565	..	Insufficient.
Talc	....	Tons	5,135	..	..	5,135	Whole . .	Sufficient.
Tin	Ore	,,	4,255	..	2,876	1,879	Considerable .	Insufficient.
	Metal (unwrought) . .	,,	..	2,095	655	1,443	Considerable .	Insufficient.
Titanium minerals .	Ilmenite . . .	,,	36,166	..	(b)	..	..	Surplus.
Tungsten . . .	....	,,	2,247·7	..	4,468	..	..	Surplus.
Zinc	Concentrates . .	,,	51,455	..	(d) 54,517	..	*Nil.*	Surplus.
	Metal (unwrought) . .	,,	..	8,694		..	Whole . .	Insufficient.
	Metal (wrought) . .	,,	..	(c) 1,878		..	Whole . .	..

(a) Total exports.
(b) Ilmenite is known to be exported from India but export figures are not available.
(c) 1930-31.
(d) Presumably mainly concentrates.

TABLE VI.—*Smelting and Refining Facilities as at 31st July, 1932.*

1	2	3	4	5	6	7
Minerals and metals.	Producer.	Custom or mine smelter or refinery.	State or Province.	Number of plants in each State or Province.	Type of smelting and refinery plants.	Output capacity in units per annum.
Pig-iron . . .	The Bengal Iron Company, Limited.	Mine smelter . .	Bengal . . .	One	Two blast furnaces and pipe casting plant.	350,000 tons pig iron per annum. 175,000 tons cast iron castings.
Do. . . .	The Indian Iron and Steel Company, Limited.	Do. . .	Do. . . .	One	Two blast furnaces.	500,000 tons per annum.
Do. . . .	The Tata Iron and Steel Company, Limited.	Do. . .	Bihar and Orissa .	One	(*a*) Five blast furnaces:—	
					A	300 tons per day average.
					B	1,000 tons per day average.
					C	800 tons per day average.
					D	1,200 tons per day average.
					E	400 tons per day average or 1,250,000 tons per annum.
Steel . . .	Do. .	Do. . .	Do. . .	One	(*b*) Four basic O. H. furnaces of 60 tons each. Three basic O. H. furnaces of 100 tons each.	800,000 tons per annum.
					Duplex Plant:— 3 Bessemer converters, 25 tons each. 2 Tilting O. H. furnaces, 250 tons each. 1 Tilting O. H. furnace, 200 tons each.	600,000 tons per annum.

(*a*) 50,000—60,000 tons of zinc concentrates are produced in milling plant and shipped to Europe for smelting.
(*b*) Subsequently sent to Bombay Mint for refining.

TABLE VI.—*Smelting and Refining facilities as at 31st July, 1932*—concld.

1	2	3	4	5	6	7
Minerals and metals.	Producer.	Custom or mine smelter or refinery.	State or Province.	Number of plants in each State or Province.	Type of smelting and refinery plants.	Output capacity in units per annum.
Ferro-manganese	The Tata Iron and Steel Company, Limited.	Mine smelter	Bihar and Orissa	..	....	Ferro-manganese is manufactured for their own use. No figures are available.
Copper-matte	Indian Copper Corporation, Limited.	Mine smelter and refinery.	Bihar and Orissa	One	Pulverised-coal fired, reverberatory furnace.	4,890 tons fire-refined copper.
Blister copper	Do.		Do.	One	Basic-lined converters.	6,000 tons yellow metal sheet.
Fire-refined copper	Do.		Do.	One	Two reverberatory type, pulverised-coal fired refinery furnaces.	
Lead (*a*)	Burma Corporation, Limited.	Mine smelter and refinery.	Burma	One	H. & H. and D. & L. sintering plants, blast furnaces producing base bullion, copper-matte and nickel-speiss. Refinery using Parke's process.	70,000—80,000 tons lead.
Silver						5,000,000—7,000,000 ounces silver.
Copper-matte						10,000—20,000 tons copper-matte.
Nickel-speiss						3,000 tons nickel-speiss.
Antimonial lead						1,000 tons antimonial lead.
Gold	The Mysore Gold Mining Company, Limited. The Champion Reef Gold Mines of India, Limited. The Ooregum Gold Mining Company of India, Limited. The Nundydroog Mines, Limited.	Mine refinery	Mysore State	Four	Retorting, smelting in oil furnaces in crucibles using Rose's Bessemerising process.	Equal to capacity of mines. Maximum output was 631,116 standard ounces in 1905. Output is sent to Bombay mint for refining.

(*a*) 50,000-60,000 tons of zinc concentrates are produced in milling plant and shipped to Europe for smelting.

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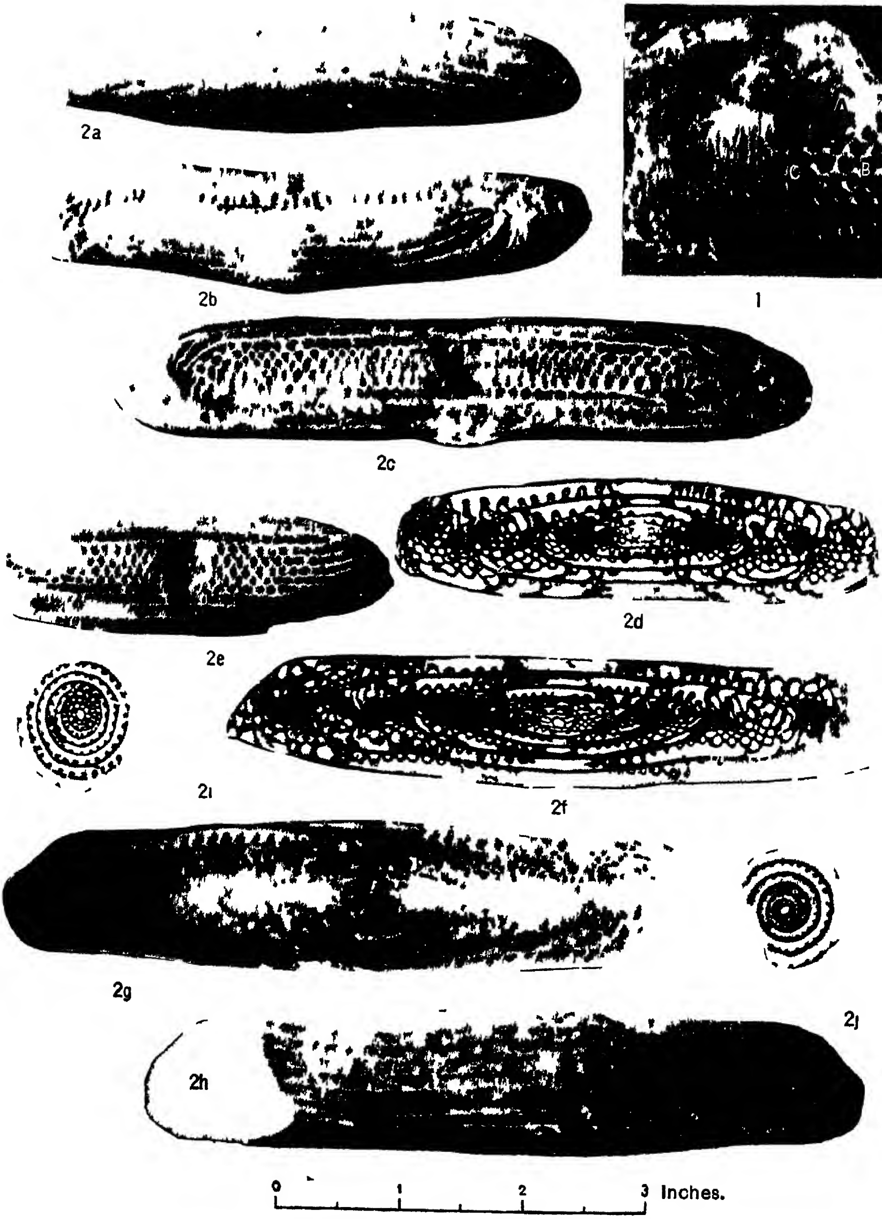
THE GEOLOGICAL SURVEY OF INDIA.



G. S. I., Calcutta.

FIG. 1. PARAFUSULINA WORDENSIS, Dunbar and Skinner.

FIG. 2. PARAFUSULINA KATTÆNSIS (Schwager).

Fig 3 (× ca 8)

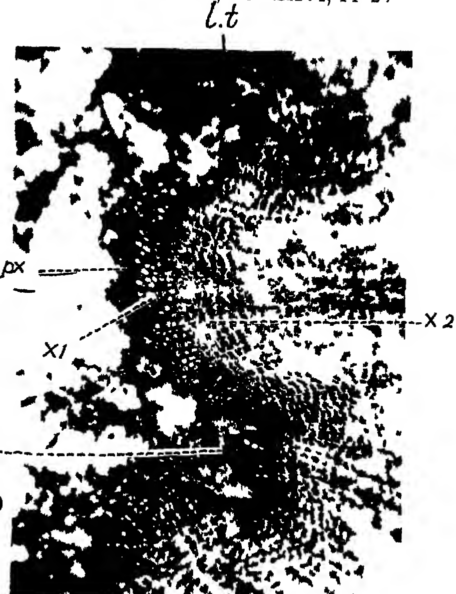


Fig 4 (× ca 45)

Fig 2 (× 1)

Fig 5 (× ca 10)

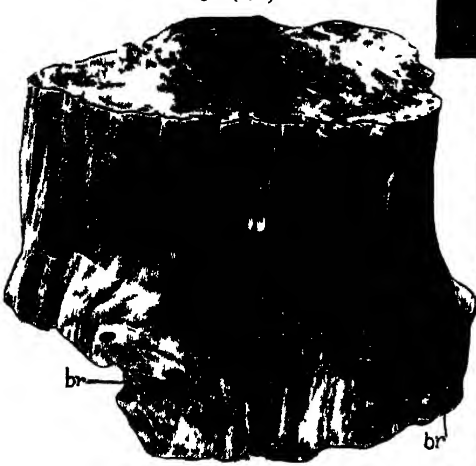


Fig 1 (× ca 2/5)

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DADOXYLON ZALESSKYI, *nov spec*

Fig 3 (× ca 70)

Fig 6 (× 17 5)

Fig 5 (× ca 360)

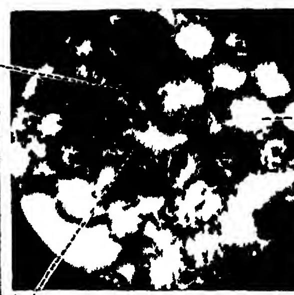

Fig 2 (× ca 142)

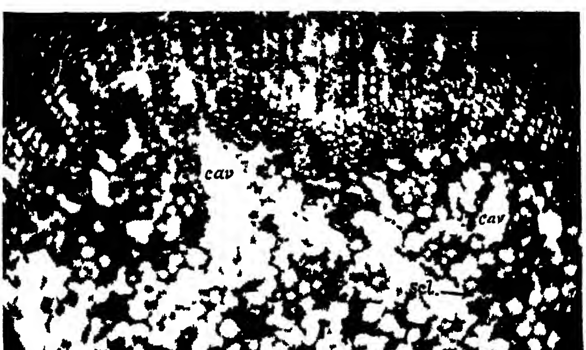

Fig 1 (× ca 51)

Fig 4 (× 450)

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DADOXYLON ZALESSKYI, *nov spec*

Fig 1 (× 1)

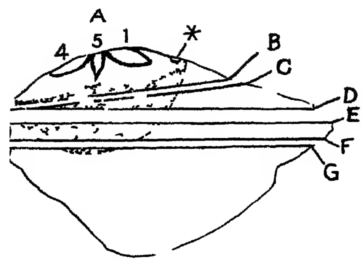

Fig 2 (× 1)

Fig 3 (× 2⅓)

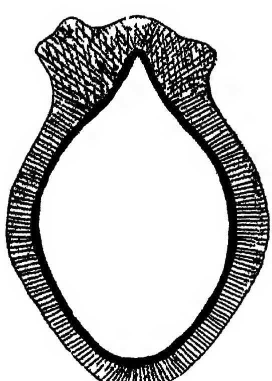

Fig 4 (× ca 5½)

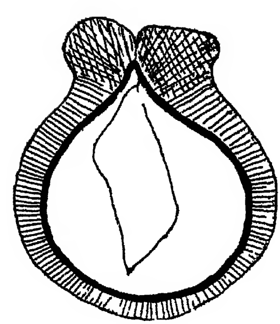

Fig 5 (× ca 5½)

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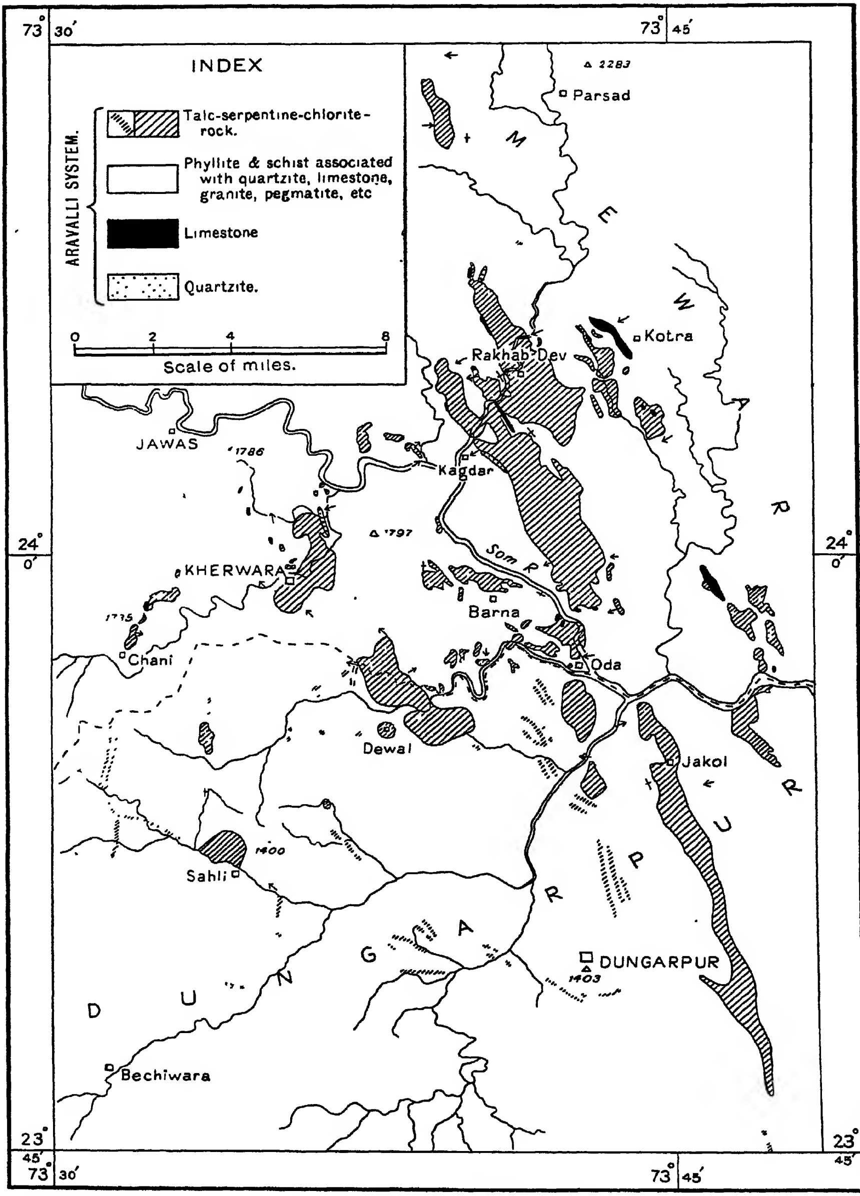
PONDICHERRIA EBENALEOIDEA, *gen et sp nov*

FIG. 1. HORNBLENDE ROCK, SHOWING HORNBLENDE WITH CLEAVAGE PLANES
Along the margin are opaque iron-ore (black) and plagioclase (white). (× 20)

P. K. Ghosh, Photomicros. *G. S. I., Calcutta*

FIG. 2. TALC-CHLORITE-ROCK WITH SMALL GRAINS AND PORPHYROBLASTS OF TITANITE, showing two systems of cleavage. (× 20.)



A. K. Chandra, Del.   Topography taken from sheets 45 H and 46 E.   G. S. I., Calcutta.

SKETCH GEOLOGICAL MAP SHOWING THE DISTRIBUTION OF THE TALC-SERPENTINE-CHLORITE-ROCKS OF SOUTHERN MEWAR AND DUNGARPUR.